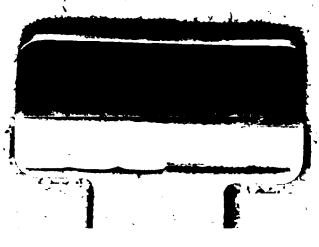

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THE PROTOZOA OF IOWA

BY CHARLES HOWARD EDMONDSON

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THE PROTOZOA OF IOWA.

A STUDY OF SPECIES KNOWN TO OCCUR IN THE WATERS OF THIS STATE

By CHARLES HOWARD EDMONDSON.

A THESIS

Submitted to the Faculty of the Graduate College of the State University of Iowa for the Degree of Doctor of Philosophy.

INTRODUCTION.

To the zoölogist the Protozoa which swarm the seas and are found abundantly in inland rivers, lakes, ponds and pools, adapting themselves to nearly every condition of moisture, offer an interesting and fruitful field for investigation.

The one-celled animals concern the student of Nature not only because of their position in the scale of animal life; not only by reason of their economic value both positive and negative, but also because many of the phenomena exhibited by highly specialized life can be explained only by a knowledge of the characteristics and behavior of these lowly organisms.

Although discovered in 1675 by Leeuwenhoek, the unicellular nature of the Protozoa was not declared with assurance until 1848, but within recent years these one-celled animals have not been unimportant factors in solving puzzling biological problems when subjected to skilful and patient experimental work. Especially have the Protozoa been a means of advancing the knowledge concerning the animal cell by the careful labor of many devoted students of science, and as a result of the concentration of attention upon the simplest of microscopic animals problems of a diverse and complex character have arisen. There is some

reason to believe, in the light of recent experimental work, that the psychical is a factor in the behavior at least of the higher forms of unicellular animals; the discovery of the relation of parasitic Protozoa to various diseases has opened up a broadening field for the pathologist, and no doubt, in the future, questions of sanitation involving the Protozoa will arise, as others have already arisen, making a knowledge of the forms which inhabit the sources of common water supplies, their life histories and the means of successfully combatting them essential for the protection of the public health. An acquaintance, therefore, with as many species as possible, their structure and the conditions under which they exist would seem to be quite desirable.

From a purely systematic point of view the one-celled animals of this country have been neglected, only a few workers here and there having devoted a portion of their time toward classifying and working out the life histories of the species in their immediate vicinities.

The purpose of this paper is to furnish a preliminary report on the species of Protozoa to be found in the waters of the state of Iowa. It is an attempt to set forth, in as plain and concise terms as possible, descriptions of species already known which inhabit the waters of this state, also calling attention to certain forms which apparently have been undescribed previous to this time. Drawings of the species observed have been made either from the living specimens or from permanent preparations, the former being in most instances preferable and more accurate as even the best of reagents may give to the delicate organisms a distorted and unreal appearance.

The entire state has not been covered in the preparation of this paper although the waters of more than thirty counties comprising the eastern, central, southern and extreme north-western portions of the state have been examined. Observations have been made over wide enough territory for us to conclude that the distribution of Protozoa in this state is quite general. For the most part, species taken from Lake Okoboji were identical with those found in the ponds, pools and small streams of the south-eastern counties of the state and, with few exceptions, species found in other localities of the state have been obtained from the waters of Johnson county where the greater part of the work for this paper

has been done. In some instances individuals of the same species have been found in widely separated regions while the species was not found in intermediate localities. This, however, is not conclusive evidence that the species did not exist in the intervening territory.

Judging from collections of material in various counties, so general seems to be the distribution of Protozoa that it is quite probable that a permanent body of water such as a small lake would, during the different seasons of the year, furnish most of the species that might be obtained from the waters of the entire state.

Although perhaps the most successful group of animals because of their minute size, the nature of their habitat, their power of encystment, rapidity of reproduction and manner of distribution, all forms of fresh water Protozoa do not indiscriminately find a habitat in similar environments. After considerable experience in collecting them one learns to know, with at least some degree of accuracy, the conditions under which species exist. Such knowledge is of some value when certain forms are desired for biological studies. Holotrichous and hypotrichous ciliates are commonly found in stagnant and bacteria-laden water, while the Mastigophora and shell bearing Rhizopods preferring a purer habitat are commonly found among algæ and other plants of low rank. Stalked peritrichous forms may be found in fresh water in running streams or quiet pools, usually attached to stones, sticks, leaves, etc. Vorticella, however, is commonly observed in stagnant pond water. For the most part, suctorians have been found among aquatic plants in fresh water.

Some species are bottom swimmers while others are found at the surface; some seek the shaded places while others are attracted by the light. It should be noted that these are only general habitats and a species may be found in very diverse environments when conditions are correct for its existence.

In making permanent preparations of Protozoa various methods may be employed. Shelled Rhizopods and forms possessing well-defined loricæ may be readily and permanently preserved by allowing them to dry on the slide, then mounting in balsam. Glycerine preparations of many forms of Protozoa may also easily be made by draining off as much water as possible after the organisms are fixed, then applying glycerine, but it is often necessary to nullify

the shrinking effect of the glycerine by a judicious use of acetic acid.

Glycerine-jelly also may be used as a mounting medium, having some advantages over glycerine. Some naked Protozoa of considerable consistency may be fixed in a drop of water, then allowing the water to evaporate, the organisms adhering to the slide may be stained, dehydrated, cleared and mounted in accord with the usual histological methods.

As a general fixing agent the fumes of osmic acid have proved very satisfactory.

In the preparation of this paper the microscopic work, for the most part, was done in the zoölogical laboratory of the State University of Iowa.

To Prof. Nutting, at whose suggestion this report was initiated, I am exceedingly grateful not only for his having placed at my disposal the best facilities afforded by the department of Zoölogy, but also for direction and encouragement in the pursuance of the work.

Profs. Wickham and Houser have also rendered assistance by way of valuable suggestions.

The classification employed in this paper is a combination derived from several sources, following quite closely, however, the scheme of Calkins in his volume, "The Protozoa," this being, it seems to me, a convenient system of grouping. No attempt is made to give a complete table of classification of Protozoa but, for the most part, only those orders and families are included, types of which have been observed or are likely to occur in the waters of this state.

TABLE OF CLASSIFICATION.

Class, SARCODINA.

Protozoa with or without shells, with pseudopodia lobose, finger-like or ray-like and sometimes anastomosing, with or without axial supports.

Sub-class, RHIZOPODA.

With or without shells, with lobose, finger-like or anastomosing pseudopodia.

Sub-class, HELIOZOA.

With or without shells, with ray-like pseudopodia usually with axial supports.

Sub-class, RADIOLARIA.

With or without a skeleton but with an internal capsule. Pseudopodia ray-like. Marine forms comprising over 4,000 species, according to Haeckel.

In this work on fresh water forms no further classification of this group will be given.

Orders of Rhizopoda.

AMŒBIDA.

With or without shells, with lobose pseudopodia.

RETICULARIIDA.

With or without shells, with finely branching and anastomosing pseudopodia. Shells usually calcareous. Mostly marine forms.

Orders of Heliozoa.

APHROTHORACIDA.

Without shells, with ray-like pseudopodia, sometimes with axial supports.

CHLAMYDOPHORIDA.

With a gelatinous or fibrous coating.

CHALARATHORACIDA.

With an outer covering of separate silicious spicules.

DESMOTHORACIDA.

With a perforated shell, sometimes stalked.

FAMILIES AND GENERA OF AMŒBIDA.

AMŒBIDÆ.

Without shells. Pseudopodia lobose or sharp-pointed, sometimes branched.

Amœba Ehr.

Dinamœba H. & L.

**Hyalodiscus* H. & L.

Round or disc-shaped, moving without distinct pseudopodia.

**Pelomyxa* Greeff.

Broad lobe-like pseudopodia, many nuclei.

ARCELLIDÆ.

With membranous shells with which may be incorporated foreign materials. Pseudopodia lobose or short-pointed, often branched.

Difflugia Leclerc.

Arcella Stein.

Centropyxis Stein.

Cochliopodium H. & L.

Pamphagus Bailey.

**Hyalosphenia* Stein.

Shell flattened, pyriform, aperture terminal, pseudopodia finger-like.

**Quadrula* Schultze.

Shell of square plates of chitin, flattened pyriform, pseudopodia finger-like.

**Nebela* Leidy.

Shell of chitinous plates of variable shapes and sizes often intermingled with foreign materials. Pseudopodia as in *Quadrula*.

EUGLYPHIDÆ.

Shells of plates of chitin or silica, sometimes spined. Pseudopodia sharp-pointed, often branched but not anastomosing.

Cyphoderia Schlum.

Euglypha Ehr.

Assulina Duj.

Trinema Duj.

**Campascus* Leidy.

Shell as in *Cyphoderia* but with lateral processes on the fundus. Pseudopodia delicate and branched.

Families and Genera of Reticulariida.

Gromidæ.

Shell sac-like, membranous. Pseudopodia extending from an opening in one end of the shell, long, branching and anastomosing.

Fresh water forms of the order are most likely to belong to this family, therefore it is introduced here.

**Gromia* Duj.

Pseudopodia forming a network about the shell.

**Microgromia* Hertwig.

Shell flask-shaped, not filled by the body. Often forming colonies.

**Pseudodifflugia* Schlum.

Shell chitinous, to which foreign materials are added. Pseudopodia delicate and branched.

Genera of Aphrothoracida.

Note.—Family names have not generally been used in the classification of Heliozoa.

Vampyrella Cienk.

Actinophrys Ehr.

Actinosphærium Stein.

Genera op Chlamydophorida.

**Heterophrys* Archer.

With fine radiating spines between the pseudopodia. (?)

**Sphærastrum* Greeff.

Outer surface lobe-like. Sometimes forming colonies.

GENERA OF CHALARATHORACIDA.

Raphidiophrys Archer.

**Acanthocystis* Carter.

With two kinds of rays: silicious rays with branched ends and delicate pointed rays as in *Actinophrys*.

GENERA OF DESMOTHORACIDA.

Clathrulina Cienk.

NOTE.—Species of genera marked with the asterisk (*) in the above table of classification have not, so far, been observed in this state.

Class, SARCODINA.
Sub-class, RHIZOPODA.
Order, AMŒBIDA.
Family, AMŒBIDÆ.

AMŒBA Ehrenberg.

With homogenous ectoplasm and more granular endoplasm. Pseudopodia lobose, finger-like or pointed. Endoplasm enclosing nucleus, contractile vesicles and inclusions.

AMŒBA PROTEUS Leidy.

Body of large size. Pseudopodia finger-like, or lobose. (Fig. 1, Pl. I.)

Amœba proteus, the first Rhizopod in point of time to come under the observation of the microscopist, is one of the most common and widely distributed.

In 1775 Rösel described this species, but it was the science of more recent times that demonstrated the minute particle of protoplasm to have the essential characters of a single living cell and to be the physiological source of specialized functions.

Various characteristics render *Amœba proteus* a most desirable subject for biological studies: it is the largest and most common species of the genus and can easily be obtained, at least in limited quantities; the differentiation between ectoplasm and endoplasm is usually well marked, the normal activity of the organism permitting the formation of pseudopodia to be readily observed,

while the simplicity of the structure reminds the thoughtful student that before his eyes is life reduced to its lowest terms.

In the formation of pseudopodia the ectoplasm is thrust out in digitate processes from various points of the periphery, to be closely followed by the granular endoplasm in a streaming movement.

Bütschli, and more recently Rhumbler, announced that as the endoplasm advances in a median axis toward the end of the newly formed pseudopodium, it flows outward and streams back along the inner surface before coming to rest. That such a backward flow does not take place has been clearly demonstrated by Jennings, the results of his observations being recorded in the sixth paper of "Contributions to the Study of the Behavior of the Lower Organisms." The cause for the formation of pseudopodia has been attributed by Verworn to the introduction of oxygen into the molecules at the surface of the body thereby reducing cohesion, the result being that surface tension is reduced. This observation is of no little significance from a biological point of view as it is believed that highly specialized muscular movements are but modifications of such a movement as is expressed in the pseudopodium of *Amœba*.

There are no fixed distinctions between the regions of *Amœba proteus*, but at times what may be termed an anterior and posterior differentiation is observed, the anterior region being the one from which pseudopodia are extended, the posterior, the part of the body following and flowing into the advancing pseudopodia.

Diatoms and other unicellular plants are the chief food of *Amœba proteus*. Ingestion of solid food particles by their being enclosed by pseudopodia and simply engulfed by the flowing protoplasm may be a matter of common observation, but the causes which underlie the process are not so clear.

Relative adhesions between the food particle and the water in which it rests on the one hand and the food particle and the protoplasm of the *Amœba* on the other hand are probable factors in the process of ingestion, but it is to be remembered that *Amœba* is a living cell, a cell in which chemical changes take place rapidly and choice of food exhibited by it, no doubt, depends upon physiological states of its protoplasm.

Although generally distributed and found almost everywhere in both stagnant infusions and fresh water *Amœba proteus* is an

isolated form, seldom being found in aggregated quantities. The common habitat is pond water in the ooze on submerged leaves, sticks, etc., but the species is sometimes found in fresh water among algæ and diatoms.

Usually a single nucleus is present, but often more than one contractile vesicle; neither nucleus nor vesicles are, however, constant in position due to the streaming movements of protoplasm. Reproduction takes place by simple cell division.

In size the individuals vary greatly. Many observed in this state have reached a length of 250 microns while other workers. have reported individuals of much larger dimensions.

AMŒBA RADIOSA Ehr.

Body a spherical mass from which radiate two or more long, slender, pointed pseudopodia. (Fig. 3, Pl. I.)

If the species previously described is characterized by activity, *Amœba radiosa* should be characterized by inactivity. Stellate in its general appearance, the organism usually rests motionless in the water with its ray-like pseudopodia as rigid as though it possessed no power of contractibility whatever. If patient in observation, however, one may occasionally see a pseudopodium slowly contract and a new one extend itself from the body.

The rays may reach a length twice the diameter of the body, are flexible and may be bent from side to side without causing them to be withdrawn.

A peculiar movement of the organism has been observed to take place. After resting motionless for some time the form may turn itself over in the water and suddenly spring backward as though under the impulse of some violent stimulus. The cause for such behavior has not been determined.

The distribution and habitat of *Amœba radiosa* is very similar to that of *Amœba proteus*. In size this species is the smallest of the genus and exceedingly variable. The diameter of the body of some individuals observed in this state has reached 45 microns.

AMŒBA VILLOSA Wallich.

Body, when active, palmate in shape, usually differentiated into a broad anterior and narrow posterior region, the latter produced into a rounded knob-like area, the surface of which presents a villous appearance. (Fig. 2, Pl. I.)

In size this species is almost as large as *Amœba proteus*, differing from the last named species, however, in possessing rather well defined anterior and posterior extremities. The species is usually remarkably active, progressing with rapidity in a definite direction by a forward rolling motion, the broad end preceding.

Pseudopodia, when they make their appearance, which is seldom, are broad and lobe-like. The villous appearance of the knob-like posterior extremity, which characterizes the species, is probably due to a rapid shrinking away of the protoplasm of this region as the animal rolls forward in its customary movement.

In appearance *Amœba villosa* is light yellowish, the endoplasm usually being crowded with food materials consisting of diatoms, algæ, etc. A nucleus and a contractile vesicle are present, the former, however, often being obscured and not observed without the use of reagents.

This species has been obtained in great numbers from the sediment at the bottom of a long standing infusion of pond water.

I have not observed the species in this state except in Johnson county, although no doubt its distribution is general.

Length, reported by Wallich, 1-50th of an inch. Specimens observed in this state, about 200 microns in length.

AMŒBA VERRUCOSA Ehr.

Body usually rounded, very transparent. Pseudopodia short, broad, blunt. Ectoplasm extensive in comparison with the more granular endoplasm. Upper surface usually wrinkled, giving the appearance of longitudinal lines.

Length, 50 microns. (Fig. 4, Pl. I.)

Amœba verrucosa, in the adult stage, is a very sluggish form, its chief movement being a slow, rolling motion, while short, lobe-like pseudopodia may be slowly extended. Immature individuals are much more active, moving with a broad extremity in advance.

The longitudinal wrinkles, of which there are usually four extending from the posterior nearly to the anterior extremity, seem to be but temporary folds of the ectoplasm. They are not at all times constant in number in the same individual and, in some, not appearing at all.

Amœba verrucosa is apparently neither abundant nor widely distributed in this state. The few individuals observed have been found in diatomaceous ooze from pond water.

DINAMŒBA Leidy.

Amœba-like, oval or elongate when active. Pseudopodia usually many. Posterior region with or without short, blunt papillæ. Body often surrounded by a zone of transparent protoplasm. Spicules present.

DINAMŒBA MIRABILIS Leidy.

Body somewhat resembling *Amœba proteus* but more regular in outline. Pseudopodia very numerous, long, finger-like, with or without minute lateral processes.

Length, as observed, 200 microns. (Fig. 5, Pl. I.)

When active, this organism extends pseudopodia from all parts of the periphery and often the body is surrounded by a broad layer of hyaline protoplasm through which the pseudpodia protrude for a considerable distance. This external layer is often marked by myriads of minute spicules which give it a striated appearance, the striæ being parallel to the long axis of the pseudopodia. The spicules may or may not be found on the extended pseudopodia. In the forms coming under my observation the posterior papillæ were usually entirely absent.

Dinamœba mirabilis is found in pond water. It feeds upon algæ, diatoms, etc., the endoplasm often being densely packed with these organisms.

Family, ARCELLIDÆ.

DIFFLUGIA Leclerc.

Body protected by a shell which is composed largely of foreign particles, commonly fine quartz sand. Mouth usually terminal, from which may be extended long, cylindrical pseudopodia, either simple or branched.

Nine species have been found in the waters of this state.

DIFFLUGIA PYRIFORMIS Perty.

Shell oval or pear-shaped, sometimes with a short neck and broadly expanded fundus with or without spines, composed mainly of sand grains. Pseudopodia slender, cylindrical, simple or branched.

Length of shell, from 50 to 300 microns.

This species is a common one and many varieties of shells must be included in it.

Figure 9, Plate II, represents a typical form of the spined variety, also possessing branched pseudopodia.

Figure 12, Plate II, is a spineless variety having a deep annulation not far from the mouth. It has been found in great abundance in Dickinson county and in other localities.

Figure 8, Plate II, illustrates a very minute variety which is frequently observed in the process of conjugation.

Difflugia pyraformis is widely distributed, found in fresh water among algæ, and usually in an active state.

During the summer of 1905 many individuals were found having the protoplasm bright green in color, due probably to previously ingested plant tissue, upon which the species ravenously feeds. The pseudopodia being adhesive are enabled to draw into the mouth such food particles as may cling to them.

Reproduction takes place, as in the other species of the genus, by the extrusion of a portion of the cell-mass and the formation of a new shell about the extruded portion, after which the two individuals separate.

DIFFLUGIA GLOBULOSA Duj.

Shell more or less spheroidal in shape, composed usually of quartz sand. Mouth large, terminal, seldom with a well-marked neck.

Length, 100 microns. (Figs. 6–7, Pl. II.)

This is one of the smallest and rarest species of the genus. All of the forms observed in this state were of the spheroidal shape represented by Fig. 6, Pl. II, with the mouth truncating the oral extremity. The fundus is usually evenly rounded, bearing no spines. The mouth, as shown by Fig. 7, Pl. II, is large, round, and without lobes.

The habitat of this species is similar to that of the other members of the genus, but seldom does one observe active individuals. Specimens were taken from Lake Okoboji during the summer of 1905, and also from the waters of Johnson county.

DIFFLUGIA CRATERA Leidy.

Shell usually of small size with an oval or rounded fundus prolonged anteriorly into a broad cylindrical neck. Mouth terminal.

Length, from 55–150 microns. (Figs. 14–15, Pl. II.)

This species is also a rare one and seldom is it found in an active condition. Fig. 14 represents the most common variety found in this state, having a rounded fundus and broad, flaring neck. Fig. 15 illustrates a curious variety found in Johnson county, having an exceedingly long neck terminating in a flaring rim. Between the distal end of the neck and the body proper were two other annular ridges, giving the appearance of a once completed shell with later additions.

Found in pond water among diatoms and other plants of low order.

DIFFLUGIA CONSTRICTA Leidy.

Shell oval in form with the anterior border obliquely truncate, composed of sand grains and other foreign materials. Fundus rounded, with or without spines.

Length, 100 microns. (Fig. 17, Plate III.)

Rarely has this species been found in the waters of this state. Fig. 17, Pl. III, illustrates a typical form of the species as observed in Johnson county. These specimens were small individuals, as Leidy reports that only the larger varieties bear spines. None of those which I have observed possessed spines. In disposition the organism is shy, seldom extending pseudopodia.

The size of the shell, according to Leidy, may range from about 90 to 200 microns in length. Those observed in this state were approximately 100 microns in length.

DIFFLUGIA ACUMINATA Ehr.

Shell usually composed of sand crystals, oblong-oval in shape, the fundus prolonged into an elongated process more or less acuminate; no spines.

This species has a wide distribution and has been found in almost every locality of the state where I have made an examination of the waters.

Figure 13, Pl. II, represents a typical form of *Difflugia acuminata*, although great variations may occur in the size and shape of the shells. The posterior acuminate process, although a characteristic of this species, may be possessed by other species. I have observed it in *Difflugia urceolata*, and an approach to it in *Difflugia cratera*. Intergrading forms are not uncommon, having characters of more than one species.

Difflugia acuminata is often found associated with *Difflugia pyriformis* in fresh water and is also in the ooze at the bottom of lakes, ponds, etc.

Length of the individual represented by Fig. 13, Pl. II, 175 microns.

DIFFLUGIA URCEOLATA Carter.

Shell of large size, fundus usually evenly rounded, seldom spined; neck short; mouth large, circular, surrounded by a reflected rim with a thin edge; pseudopodia as in *Difflugia pyriformis*.

Length, 250–300 microns. (Fig. 19, Pl. III.)

In size this is the largest species of the genus. Its distribution over the state is, apparently, not very general, few localities having furnished it. The best specimens have been obtained from pond water in Muscatine county. Lake Okoboji, from which, in August, 1905, were taken great quantities of other species of *Difflugia*, furnished none of *Difflugia urceolata*.

Prof. Leidy reports a spined variety of this species from New Jersey. None of the forms found in this state were spined. Fig. 19, Pl. III, represents a variety of *Difflugia urceolata* which is typical except for the possession of the posterior acuminate process which, however, would hardly be considered a spine.

Pseudopodia are of the common digitate variety, rarely being branched.

DIFFLUGIA LOBOSTOMA Leidy.

Shell small, oval, usually composed of fine sand grains; mouth terminal, small, with three or four well-marked lobes; pseudopodia as in other members of the genus.

Length, 95 microns. (Figs. 10–11, Pl. II.)

Figure 10, Plate II, illustrates a typical form of *Difflugia lobostoma* as it is usually observed resting on the water.

Figure 11, Plate II, is an oral view of an individual of the same genus, showing the lobed nature of the mouth. The species is a very common one in pond water and has a wide distribution, being found in many localities in this state.

Normally the organism rests upon its side, but by turning it so that the mouth is visible it may easily be determined whether or not it meets the requirements of this species.

Those possessing the three-lobed mouth are the most common forms of this state.

DIFFLUGIA CORONA Wallich.

Shell spheroidal, composed of particles of quartz sand, the fundus usually being spined. Mouth terminal, circular, with a notched border.

Length, 175 microns. (Fig. 16, Pl. III.)

Difflugia corona is one of the larger species of the genus. The distribution is general, being found in great abundance in many localities in the state. Lake Okoboji, during the summer of 1905, furnished myriads of this species. Commonly *Difflugia corona* may be found resting with its mouth downward while the cylindrical pseudopodia protrude in a radiating manner.

The small tooth-like processes bordering the mouth may vary in number but are usually more than ten. The number of spines also varies, but seldom less than four or five to an individual have been observed. Frequently found among algæ.

DIFFLUGIA SPIRALIS Ehr.

Shell retort-shaped with an evenly rounded fundus, latterly compressed. A short neck usually produced.

Length, 125 microns. (Fig. 18, Pl. III.)

This species is a rare one in this state, having been found but a few times and only in Johnson county.

The spiral appearance of the shell is due to an interior partition arising from the concavity of the side of the body and extending in an upward curve toward the other side. This partition does not entirely separate the cavity but serves as a wall, behind which the protoplasm may retract. When viewed through the more or less transparent shell the partition resembles a dark line.

Found in pond water among aquatic plants.

ARCELLA Ehrenberg.

Body secreting a shell of chitinoid material, semi-spheroidal in shape when viewed laterally, usually circular when viewed dorsally or ventrally; mouth central; pseudopodia digitate or broadly lobate, never branched. Nuclei and contractile vesicles usually more than one.

ARCELLA VULGARIS Ehr.

Shell usually some shade of yellow or brown, about one-half as high as broad, the character of the surface varied. Mouth circular, in the center of the ventral surface.

Diameter of shell, 75 microns.

Arcella vulgaris is one of the most common of fresh-water Rhizopods, being found nearly everywhere in small streams, lakes and ponds.

The shell varies in color from pale yellow, which indicates a young individual, to dark brown, indicating advanced age. The species also varies greatly in the character of the markings of its surface; commonly the shell presents a cancellated appearance, the punctæ being arranged with regularity. In older individuals, however, this character may disappear and no trace of the punctæ be found. Sometimes the convex surface is ornamented by shallow concavities arranged with more or less regularity.

Other markings of the surface may also occur.

Figure 20, Plate III, illustrates a common variety, the punctæ, however, not appearing in this individual. Fig. 21 shows a somewhat rarer variety, the surface being marked with shallow concavities.

Conjugation has often been observed to take place by the temporary union of the ventral surfaces of the two individuals, as represented by Fig. 22. During the fall of 1903 many individuals taken from the pond water in Johnson county were seen to undergo reproduction, a portion of the protoplasmic mass first being pushed out from the individual's mouth and resting upon it in spherical form, yet connected with the protoplasm within the shell. (See Fig. 23, Pl. IV.)

From the extruded portion another shell is secreted, very transparent at first, the two individuals finally separating. Fig. 24 represents an advanced stage in the process, the shells to the left and right being the mother and daughter *Arcella* respectively, the latter drawing into itself a sufficient quantity of protoplasm before separating from the parent.

Sometimes compact masses comprising a score or more of individuals of this species may be seen adhering to each other, floating in the water.

In members of this genus the protoplasmic body of the individ-

ual does not completely fill the shell but is attached to the inner surface by means of minute threads. By the liberation of carbon dioxide within the shell, at any point, the organism has the power to change its position in the water at will by changing its specific gravity; thus the species may raise itself in the water or turn on its side. At least two nuclei are usually present, opposite in position. Contractile vesicles may be numerous.

ARCELLA DISCOIDES Ehr.

Shell comparatively large, flattened, disc-like. Mouth circular and of large diameter.

Diameter of shell, 125 microns. (Figs. 25–26, Pl. IV.)

This species differs from the preceding one in three particulars: the diameter of the shell, the height of the dome, and the diameter of the mouth.

The height of *Arcella discoides* is frequently less than one-fourth its diameter and the diameter of the mouth often equals one-half the diameter of the shell.

Figure 26, Plate IV, represents a typical form of this species from a lateral point of view. Fig. 25 is a dorsal view showing extended pseudopodia.

The surface of *Arcella discoides* is usually marked by punctæ but no shallow concavities have been observed as in the case of *Arcella vulgaris*.

Although widely distributed the individuals are usually isolated, not appearing in aggregate quantities. A few specimens have been observed in many localities of this state. Found in pond water among aquatic plants and often associated with *Difflugia*.

CENTROPYXIS Stein.

Shell composed of chitinous material with the addition of sand grains, diatom shells, etc.; ovoid in shape with the mouth and fundus eccentric in opposite directions. Spines usually present.

CENTROPYXIS ACULEATA Stein.

Having the characters of the genus.

Length of shell, 150 microns.

Diameter of mouth, 60 microns. (Figs. 27–28, Pl. IV.)

Centropyxis may be considered as an intermediate form between *Arcella* and *Difflugia*, resembling the latter, however, more than the former. The appearance of *Centropyxis* is as if *Difflugia* were compressed dorso-ventrally and laterally, resulting in the eccentricity of the mouth and fundus. Of the foreign material making up the shell quartz sand predominates, thus giving to the organism the external appearance of *Difflugia*, its coloration, however, usually being some shade of brown.

The fundus is often provided with spines which are longer and more slender than those of *Difflugia* and which are seldom with any addition of foreign material.

From one to six or eight spines are usually present. A spineless variety has been observed on a few occasions in this state.

Centropyxis is noted for its shyness. Only once have I found the species in an active condition. Fig. 28 illustrates a lateral view of the active individual with a single, long, cylindrical pseudopodium extended. Fig. 27 is a ventral view of a spined form.

Centropyxis aculeata is widely distributed over the state, frequently found in great numbers among algæ.

COCHLIOPODIUM Hertwig and Lesser.

Shell a delicate, transparent membrane, exceedingly flexible. Protoplasm granular and in close contact with the inner surface of the shell. Mouth capable of becoming greatly expanded as its borders are reflexed.

COCHLIOPODIUM BILIMBOSUM Leidy.

Body with the characters of the genus but having no hair-like appendages. Endoplasm colorless.

Diameter of shell, 60-90 microns. (Fig. 29, Pl. V.)

This minute organism, in general appearance, somewhat resembles *Amœba*, and Auerbach first described it as belonging to that genus. The shell is very plastic and corresponds to the amœboid movements of which the animal is capable.

When viewed from above sometimes the body seems to be surrounded by a zone of exuded protoplasm, this apppearance, however, being due to the great reflection of that region of the shell bordering the mouth. This great expanse of the mouth may be observed when the organism is viewed laterally, the membranous shell then appearing as a double contour line bordering the body.

The pseudopodia are transparent, variable in length, sharp pointed and may be branched or not but do not anastomose. A large spherical nucleus is present but usually not visible without the aid of reagents.

Sometimes found in great abundance in pond water among diatoms, upon which it feeds.

Cochliopodium vestitum, differing from the above species chiefly in the shell being covered with rigid cilia and in the green color of the endoplasm, probably also appears in this state but has not so far been observed.

PAMPHAGUS Bailey.

Body enclosed within a transparent, elastic membrane. Endoplasm completely filling the membrane, more or less granular. Mouth small, terminal. Pseudopodia long, delicate, branching but not anastomosing.

PAMPHAGUS MUTABILIS Bailey.

Body ovoid in shape, seldom changing form, the oral extremity more acutely rounded than the fundus. Mouth small, often indicated only by the region from which the long, delicate pseudopodia are extended. Nucleus large, spherical.

Length, 60 microns. (Fig. 32, Pl. V.)

This organism is not common in the waters of this state, but it is very active, usually being found with its long branching pseudopodia widely extended.

The closely investing covering of the body prevents any great distortion, although slight changes of form sometimes occur. As a result of stimuli the organism withdraws its pseudopodia and assumes a rounded or spherical form.

Pamphagus, no doubt, represents a development of *Amœba* to such an extent that the ectoplasm has become differentiated to form a resisting membrane. The plate figure represents an individual taken from a running stream near Iowa City in December, 1905. Found in the ooze at the bottom of ponds, rivers and lakes.

Family, EUGLYPHIDÆ.

CYPHODERIA Schlumberger.

Shell composed of chitinous material, curved backward from the mouth, retort-shaped. Pseudopodia delicate and branching.

CYPHODERIA AMPULLA Leidy.

Shell composed of minute hexagonal plates, often punctate, and arranged in oblique rows. Fundus evenly rounded or produced into a conical process.

Length, 160 microns. (Fig. 35, Pl. V.)

The color of *Cyphoderia* is usually some shade of yellow or brown, as in *Arcella*, age being indicated by the density and opaqueness of the shell.

In some individuals of dark brown color no indications of the hexagonal form of the plates which compose the shell are to be seen. The surface, as in *Arcella*, is curiously ornamented with punctæ which are usually arranged with regularity.

Leidy reports that the pseudopodia are very delicate, branching but not anastomosing.

The species is exceedingly rare in this state, and no active individuals were among those found.

Habitat, the ooze at the bottom of rivers, lakes and ponds.

EUGLYPHA Dujardin.

Shell chitinous, transparent, composed of plates arranged in longitudinal rows overlapping each other. Usually oblong-oval, circular in transverse sections. Fundus broadly rounded, often bearing spines. Mouth truncating the narrow extremity, with serrated border. Pseudopodia delicate, simple or branched.

EUGLYPHA ALVEOLATA Duj.

Shell composed of oval plates overlapping each other and arranged in regular rows producing the appearance of hexagonal areas. Spines often present.

Length of shell, 100 microns. (Fig. 31, Pl. V.)

Euglypha alveolata is a common Rhizopod, being found almost everywhere in fresh water among algæ or in the ooze at the bottom of ponds and lakes.

The spines when present are long, slender and often curved, usually scattered over the surface of the shell. Spineless forms, however, have been much more common in this state than spined ones. Often the demarkation of the plates is indistinct, the shell appearing as a homogenous structure.

The species is shy in disposition, active individuals seldom

being observed. Fig. 31 illustrates a spineless variety with pseudopodia almost withdrawn.

ASSULINA Ehrenberg.

Shell of chitinous material, oval in shape, compressed, usually made up of hexagonal plates. Mouth truncating the oral extremity, elliptical, with uneven edges. Pseudopodia as in *Euglypha*.

ASSULINA SEMINULUM Leidy.

Having the characters of the genus.

Length, 40 microns. (Fig. 30, Pl. V.)

The shell ranges in color from transparency to dark brown, probably depending upon the age. The hexagonal plates are arranged in alternating rows and about the oral aperture are placed so as to give a notched appearance to the border.

Pseudopodia are exceedingly delicate and transparent, branched but not anastomosing.

The species is apparently a rare form in the state, but few specimens having been found. Seldom may one see the organism with its pseudopodia extended. Its habitat is the ooze at the bottom of ponds.

TRINEMA Dujardin.

Body enclosed within an elongated, chitinous shell; fundus rounded, oral extremity narrower and obliquely truncate. Mouth circular, sub-terminal, in the center of the truncated border. Pseudopodia very delicate and transparent.

TRINEMA ENCHELYS Leidy.

Having the characters of the genus.

Length, 40 microns. (Figs. 33–34, Pl. V.)

Usually the shell of *Trinema enchelys* presents a homogeneous appearance with a smooth outline, but in some specimens the shells show evidence of being made up of minute oval plates.

In size the species varies greatly, as also in the density of the material composing the shell. Some are transparent while others are completely opaque.

Figure 33, Plate V, represents a form of the apparently homogeneous variety, it being a ventral view. Fig. 34 represents the same form from a lateral point of view.

Trinema enchelys is one of the smallest and most abundant of fresh water Rhizopods. Its distribution is wide, being found in many localities of this state. It is commonly found in the ooze at the bottom of ponds and among diatoms and algæ.

Sub-class, HELIOZOA.
Order, APHROTHORACIDA.

ACTINOPHRYS Ehrenberg.

Body a spherical mass of granular protoplasm from which radiate delicate, tapering, ray-like pseudopodia. Nucleus and contractile vesicles conspicuous.

ACTINOPHRYS SOL Ehr.

Body of granular protoplasm, without chlorophyl. Diameter of body, 100 microns. (Fig. 36, Pl. V.)

The normal appearance of *Actinophrys sol* as it rests in the water is a spherical mass of highly vesicular protoplasm with its ray-like pseudopodia in an active state of extension and retraction.

Among the many vesicles one or more are contractile. Before bursting the contractile vesicle or vesicles rise to the surface, push out the periphery as large, semi-spherical, transparent globules and then suddenly collapse.

The nucleus is large, spherical, central in position and may or may not be visible without the aid of reagents.

Reproduction may frequently be seen to take place by simple fission, a constriction of the body mass occurring and the two portions drawing apart.

The species has been found in great abundance in spring water in the vicinity of Iowa City, but also may be found in more stagnant pond water.

Its distribution is very general.

ACTINOPHRYS PICTA Leidy.

Protoplasm of body as in *Actinophrys sol*, but bright green in color due to the presence of chlorophyl. Diameter of body approximately that of *Actinophrys sol*.

Many forms of the above description have been found in spring water near Iowa City associated with *Actinophrys sol*. In size and

general appearance, except for the green color, they are identical with the last species.

It seems not at all improbable that the green forms observed in this state as well as *Actinophrys picta* of Leidy may be but a variety of *Actinophrys sol.*

No illustration of this green variety has been made owing to its close resemblance to *Actinophrys sol.*

ACTINOSPHÆRIUM Stein.

Body spherical, of large size, protoplasm granular, differentiated into an outer highly vesiculated zone and a denser interior region. Pseudopodia with thick bases, tapering, with axial supports. Nuclei many.

ACTINOSPHÆRIUM EICHHORNII Stein.

Having the characters of the genus.

Diameter of the body, 150 microns. (Fig. 41, Pl. VI.)

The body is of granular protoplasm with a well marked and very transparent peripheral region which is highly vesiculated; usually two or more of these vesicles are contractile exhibiting the same phenomena just before systole as the contractile vesicles of *Actinophrys sol.* The large, ray-like pseudopodia possess rigid yet flexible axial supports which originate from the inner surface of the vesiculated border.

The inner and more dense region of the body may be almost completely filled with small spherical nuclei. I have observed individuals possessing more than sixty nuclei.

The species is not a common one in this state but has been found associated with *Actinophrys sol* in fresh water.

Figure 41, Plate VI, illustrates one-half of a typical specimen.

VAMPYRELLA Cienkowsky.

Body spherical, capable of amœboid movements. Pseudopodia of two varieties, capitate and simple, ray-like.

VAMPYRELLA LATERITIA Fres.

Body spherical, granular in appearance, sometimes brick or orange red in color, sometimes colorless. Capitate pseudopodia the more numerous, arising from all points of the periphery.

Diameter of the body, 30 microns. (Figs. 37–38, Pl. VI.)

This rare and remarkable organism has come under my observation but once, the individual being dark granular in appearance, the endoplasm crowded with minute spherical, oil-like globules. Leidy reports that the body of *Vampyrella* may be of a brick or orange-red color.

The peculiar characteristic of the species is that it possesses two varieties of pseudopodia, the more numerous capitate variety, each having a short stem ending in a minute round head. These are usually projected and withdrawn with great rapidity. A few simple pseudopodia like those of *Actinophrys sol* are intermingled with the capitate variety. Normally the organism rests quietly in the water, but if the microscopist is patient some strange phenomena may be observed. Suddenly, as if not pleased with its surroundings, the animal begins to elongate itself, acquiring an oblong-oval form. The capitate pseudopodia are still active, the simple rays at the region of the body now corresponding to the anterior are withdrawn, while those at the opposite extremity begin to vibrate and the organism slowly moves through the water.

Figure 37, Plate VI, illustrates the normal individual at rest. Fig. 38, Pl. VI, represents the organism during its amœboid phase, as observed by the author.

After a period of more or less duration the animal again comes to rest, the spherical shape is assumed and the vibrating pseudopodia become simple and ray-like once more.

Such phenomena as are exhibited by *Vampyrella lateritia*, are, I believe, of no little significance to the biologist. The sudden transformation of pseudopodia into flagella, and vice versa, is a visible example of the close relationship between amœboid and ciliary movements. The cause or causes underlying such phenomena are not easily determined. Wonderful must be the metabolism in this bit of protoplasm to bring about such marvelous physiological changes.

Found in Johnson county, in fresh water, among diatoms and other one-celled plants.

Order, CHALARATHORACIDA.

RAPHIDIOPHRYS Archer.

Body spherical, composed of granular protoplasm, often bright

green in color. A dense zone of tangentially arranged spicules on the periphery. Pseudopodia as in *Actinophrys sol.*

RAPHIDIOPHRYS VIRIDIS Archer.

Found usually in aggregated groups of variable number. Bodies colorless or filled with green chromatophores. Spicules conspicuous and slightly bent.

Diameter of the body, 75 microns. (Fig. 39, Pl. VI.)

What I have considered to be isolated forms of this species have frequently been found in Johnson county, although none at the time of observation were chlorophyl bearing. The presence and arrangement of the peripheral layer of spicules, however, leads me to believe that the organism should be classified here. At times these bacteria-like spicules are tangentially arranged in the investing layer of protoplasm, the body presenting a smooth contour; frequently, however, the spicules are arranged more radially, crossing each other at sharp angles and may be seen extending along the bases of the pseudopodia. The pseudopodia are ray-like, equalling in length the diameter of the body.

Reproduction has often been observed to take place as in *Actinophrys sol.* Found among algæ.

Figure 39, Plate VI, illustrates a specimen from Johnson county.

Order, DESMOTHORACIDA.

CLATHRULINA Cienkowsky.

Body spherical, enclosed within a latticed capsule and attached by a stem. Pseudopodia simple, ray-like.

CLATHRULINA ELEGANS Cienk.

Protoplasm of the body granular, when mature enclosed within a capsule of silicious material, and attached by a thread-like, tubular stem.

Diameter of capsule, 45 microns. (Figs. 40 and 42, Pl. VI.)

This species is one of the most beautiful of fresh water Protozoa. It is, however, a rare form. The latticed shell is a mark of maturity, young forms for a period after separation from the parent cell showing no indication of such a covering.

Pseudopodia which protrude through the irregular shaped openings of the shell are in all respects similar to those of *Actinophrys.*

It has been my privilege to observe the process of the formation of the stem by which *Clathrulina elegans* attaches itself to some support, usually aquatic plants. A naked individual, the result of recent fission, came under observation, swimming freely for a time; then a cone-shaped outpushing of the protoplasm took place on one side, the protoplasm adhering to a particle of plant tissue, and a stem began to develop. After three hours the stem had reached its normal length, which is about one and one-half times the diameter of the body.

Figure 40 illustrates a normal adult individual. Fig. 42 represents an earlier phase in the animal's life.

Found in fresh water among aquatic plants.

TABLE OF CLASSIFICATION.

Class, MASTIGOPHORA.

Small forms of Protozoa provided with one or more flagella. Often forming colonies.

Sub-class, FLAGELLIDIA.

Naked or enclosed by a membrane. One or more flagella arising from or near the anterior end.

Sub-class, DINOFLAGELLIDIA.

Often provided with shells and usually having at least two furrows, one transverse and one vertical. Flagella usually two, one directed around the body and one away from it. Mostly salt water forms.

Sub-class, CYSTOFLAGELLIDIA.

Flagellates of large size, enclosed by a firm membrane. Salt water forms. No further classification of this group is given in this paper.

Orders of FLAGELLIDIA.

MONADIDA.

Small forms, sometimes amœboid, with no distinct mouth. Flagella one or two.

CHOANOFLAGELLIDA.

Flagellum single, about the base of which is developed a membranous collar. Often forming colonies.

HETEROMASTIGIDA.

Flagella two or more, one directed forward. Bodies transparent and often very plastic.

POLYMASTIGIDA.

Flagella often numerous, at the base of which food is ingested, there being no distinct mouth.

EUGLENIDA.

Flagella one or two at the base of which is a mouth. Often possessing chlorophyl.

PHYTOFLAGELLIDA.

Plant-like flagellates with or without color. An indurated membrane or shell sometimes present. Flagella one or more.

Orders of DINOFLAGELLIDIA.

DINIFERIDA.

Body with two transverse furrows. Members of other orders of the sub-class not likely to occur in fresh water.

Families and Genera of Monadida.

RHIZOMASTIGIDÆ.

With amœboid body capable of forming pseudopodia. One or more flagella. No distinct mouth.

Mastigamœba Schultze.

Acinetactis Stokes.

**Cercobodo* Krass.

Two flagella, one trailing.

**Cercomonas* Duj.

Form changeable but usually pointed behind. Flagellum single.

HETEROMONADIDÆ.

Small, transparent flagellates with one prominent flagellum and one or more smaller ones. Sometimes forming colonies.

Anthophysa Bory d. St. V.

**Monas* Stein.

Body more or less spherical or oval, sometimes attached by the narrow posterior extremity. Not forming colonies.

**Cephalothamnium* Stein.

Body pyriform, anterior border oblique. Forming colonies at the extremities of a branched pedicle.

Families and Genera of Choanoflagellida.

CRASPEDOMONADIDÆ.

Solitary or forming colonies. Individuals, naked, inhabiting loricæ or embedded in a gelatinous mass.

Monosiga Kent.

Codosiga James-Clark.

Families and Genera of Heteromastigida.

BODONIDÆ.

Minute forms with flagella of nearly equal size. No lorica or membranous covering.

Heteromita Duj.

**Phyllomitus* Stein.

Body elongate-oval, mouth prominent. One of the two flagella trailing.

Families and Genera of Polymastigida.

POLYMASTIGIDÆ.

Flagella usually arranged in two groups. Food ingested at the base of each group.

Trepomonas Duj.

**Hexamitus* Duj.

With four anterior vibratile flagella in two groups, and two trailing flagella.

Families and Genera of Euglenida.

EUGLENIDÆ.

Elongated forms usually with a single flagellum. Pigment spot and chlorophyl often developed.

Euglena Ehr.

Phacus Nitzsch.

Chloropeltis Stein.

Cryptoglena Ehr.

Trachelomonas Ehr.

**Eutreptia* Perty.

With two similar flagella, otherwise as *Euglena*.

**Ascoglena* Stein.

Similar to *Euglena* but inhabiting a sessile tubular lorica.

**Colacium* Ehr.

Similar to *Euglena*, free-swimming or attached to a branched pedicle.

ASTASIIDÆ.

Body elongated but plastic with no coloring substance. Flagella one or two.

Astasia Ehr.

Distigma Ehr.

**Menoidium* Perty.

Lunate, flattened. Flagellum single. Endoplasm granular.

**Atractonema* Stein.

Elongated, spindle-shaped. Flagellum single, very long. Pharynx distinct.

PERANEMIDÆ.

Body persistent in shape and plastic. Flagella one or two. Pharynx distinct.

Heteronema Duj.

Petalomonas Duj.

Anisonema Duj.

Entosiphon Stein.

**Zygoselmis* Duj.

Exceedingly plastic, resembling *Astasia* but with two flagella.

NOTOSOLENIDÆ.

Persistent in shape. Flagella two, the trailing one very short. Oral aperture indistinct. Endoplasm colorless.

Notosolenus Stokes.

FAMILIES AND GENERA OF PHYTOFLAGELLIDA.

CHRYSOMONADIDÆ.

Usually enclosed by a gelatinous mass or firm membrane. Flagella one or two. Often enclosing colored pigment bands.

Nephroselmis Stein.

Mallomonas Perty.

**Ochromonas* Wysotzki.

Somewhat pear-shaped but changeable in form. Flagella two, unequal. Yellow chromatophores usually present.

**Microglena* Ehr.

Ovate or elongate, plastic. Flagellum single. Two yellow color bands usually present.

CRYPTOMONADIDÆ.

Never amœboid. Flagella two, very similar, color bands sometimes present.

Chilomonas Ehr.

Cryptomonas Ehr.

**Cyathomonas* From.

Ovoid, flattened laterally. Flagella two, equal. Endoplasm colorless with a row of refracting bodies near the anterior border.

CHLAMYDOMONADIDÆ.

Body enclosed by a rigid, membranous sheath which is perforated for the flagella. Chromatophores present.

Chlamydomonas Ehr.

FAMILIES AND GENERA OF DINIFERIDA.

PERIDINIDÆ.

With or without a shell. The cross-furrow near the middle of the body. The only family represented in fresh water.

**Gymnodinium* Stein.

Cross-furrow encircling the body.

**Glenodinium* Stein.

Membrane enclosing the body thin, with no processes.

**Peridinium* Ehr.

Membranous covering composed of polygonal plates. Processes not highly developed.

NOTE.— In the above classification, with the exception of *Peridinidæ*, only families, representatives of which have been observed to occur in this state, have been included. Species of the genera marked with an asterisk (*) have not so far been observed in this state, but are likely to occur.

Class, MASTIGOPHORA.
Order, MONADIDA.
Family, RHIZOMASTIGIDÆ.

MASTIGAMŒBA Schultze.

Very plastic and changeable in form. Pseudopodia often extended from the body, bluntly rounded, finger-like or pointed,

sometimes branched. A single flagellum arising from the anterior extremity.

MASTIGAMŒBA sp.

Body elongated, wider posteriorly. Pseudopodia extending from all points of the surface, short, finger-like, unbranched. Flagellum longer than the body, with a broad base. Nucleus spherical; contractile vesicle single.

Length, 15–25 microns. (Fig. 43, Pl. VII.)

A minute form corresponding to the above description has been observed in pond water from several localities in this state. In some respects the organism conforms to *Mastigamœba simplex* S. K., although the Iowa variety is usually wider posteriorly and the pseudopodia are smooth.

This species, as others of the genus, may be considered as occupying an intermediate position between the *Sarcodina* and *Mastigophora*, possessing as it does some striking characters of the former. There is, however, not such a marked differentiation between the endoplasm and ectoplasm as in *Amœba*, which it resembles, the outer surface also offering greater resistance to the endoplasm than in *Amœba*.

The flagellum shows indications of being an intermediate structure, it apparently being but a prolongation of the anterior extremity of the body with a broad base as if a tapering pseudopodium were long drawn out and endowed with the power of vibration.

No indications of a mouth are present, the food probably being ingested at any point in the surface as in *Amœba*.

Habitat, pond water among diatoms and other unicellular plants. Found in Van Buren, Louisa and Johnson counties.

ACINETACTIS Stokes.

Spheroidal in shape, capable of extending capitate pseudopodia from all points of the periphery. Flagella two in number, approximately equal in length.

ACINETACTIS MIRABILIS Stokes.

Body nearly spherical, with slender capitate pseudopodia extending from all parts of the periphery, these pseudopodia also bear one or more protoplasmic swellings along the course of the

rays; short, lobate pseudopodia also may sometimes be present. Flagella two in number, nearly equal in length, originating from the anterior border some distance apart.

Diameter of the body, 10–15 microns. (Fig. 44, Pl. VII.)

This organism also stands on the border line between the *Sarcodina* and *Mastigophora*, possessing some characters of each, and by way of such forms as this must be traced the ascent from the lowest unspecialized, to the more highly organized protozoan cells.

No oral opening has been observed and no doubt *Acinetactis mirabilis* ingests food as does *Amœba*, the pseudopodia serving similar functions in both animals.

By stimuli of various sorts the organism may be induced to withdraw its pseudopodia entirely and then, in appearance, it resembles a true flagellate.

I have observed reproduction to take place by longitudinal fission, the point of division being between the flagella, an additional flagellum being formed on each portion before complete separation. One or two contractile vesicles are present, also a centrally located spherical nucleus.

Figure 44, Plate VII, illustrates a normal individual. Found but a few times in this state. Habitat, pond water.

Family, HETEROMONADIDÆ.

ANTHOPHYSA Bory d. St. Vincent.

Animals united in compact clusters, often attached to a somewhat rigid, simple or branched stalk. Bodies pear-shaped, each with two flagella of unequal length.

ANTHOPHYSA VEGETANS Müll.

Bodies attached in rosette-like clusters, each zoöid pyriform in shape, obliquely truncate anteriorly, provided with two flagella of unequal length. Clusters often attached to a branched pedicle.

Length of body, 5-10 microns. (Figs. 47-48, Pl. VII.)

Many diverse opinions concerning this species have been held by authorities. Some have regarded it as an aquatic fungus, while others have considered it to be an intermediate organism between the plant and animal series.

Often myriads of detached clusters of the species may be seen rolling through the water in the fashion of *Volvox*. The clusters are composed of zoöids from a few in number to fifty or sixty bound together rosette-like by some substance which disintegrates very quickly under the action of chemicals.

Each zoöid is more or less transparent, has a nucleus, contractile vesicle and two flagella unequal in length and, for a time at least, can lead an independent existence. Large clusters break up into small groups of four or five zoöids and by longitudinal fission of these the normal size of the cluster is again reached.

Sometimes a number of clusters are found attached to the terminations of a branched stalk. This pedicle is a product of excretion and is longitudinally striated. In older stages the stalks are dark brown in color and may be seen in large tangled masses devoid of zoöids. Fig. 47, Pl. VII, represents a detached cluster and Fig. 48, Pl. VII, shows the branched pedicle with clusters of zoöids attached.

Found nearly everywhere in stagnant and fresh water.

Order, CHOANOFLAGELLIDA.
Family, CRASPEDOMONADIDÆ.

CODOSIGA James-Clark.

Animals forming a colony, usually attached by means of a branched, rigid stalk. Bodies oval or spherical with a prominent collar. Flagellum single.

CODOSIGA BOTRYTUS Ehr.

Bodies ovate, zoöids few in number, attached to the extremity of a long, slender, rigid pedicle. Flagellum long. Collar equalling the body in length. Nucleus spherical, centrally located.

Length of body, 10–15 microns. (Fig. 49, Pl. VII.)

In this species the zoöids appear to be attached to the pedicle by means of short secondary branches, but these, according to Kent, are but the extensions of the posterior regions of the zoöids and during longitudinal fission also undergo division.

The same authority reports another interesting phenomenon exhibited by *Codosiga botrytus*, stating that before passing into the encysted state the zoöids become amœboid, pseudopodia-like processes being projected from the body and even from the collar.

The species has been found many times usually attached to aquatic plants. Fig. 49, Pl. VII, illustrates an individual from Johnson county.

Commonly the number of zoöids attached to one pedicle, as observed by the writer, has been from four to eight.

The stalk may reach six or eight times the length of a single zoöid.

MONOSIGA S. K.

Not forming colonies. The body oval or spherical, sometimes changeable in form, sessile or with a short stalk. Collar prominent. Flagellum single.

MONOSIGA STEINII S. K.

Body ovate, wider centrally, tapering toward each extremity, attached in a sessile manner to some support. Collar nearly equalling the body in length.

Length of body, 12–15 microns. (Fig. 45. Pl. VII.)

The minuteness of size renders impossible a very satisfactory study of this organism. It is found usually attached to the pedicle of some species of *Vorticella*.

During the summer of 1905 it was found in abundance attached to the stalk of *Vorticella campanularia* in a running stream near Iowa City. The species has also been observed attached to the pedicle of *Vorticella convallaria*. As many as fifteen or twenty of these minute collared flagellates may be seen adhering to the contractile stalk of a single *Vorticella*. By the use of reagents a centrally located, spherical nucleus may be brought to view.

Order, HETEROMASTIGIDA.
Family, BODONIDÆ.

HETEROMITA Dujardin.

Body usually oval or elongate but changeable in form. Flagella two in number, arising from the anterior or lateral borders of the body, one directed forward vibratile, the other trailing. No distinct mouth.

HETEROMITA sp.

Figure 50, Plate VII, represents a species observed in this state which, without doubt, must be referred to this genus.

The species, as most others of the genus, was exceedingly minute. From near the anterior extremity of the elongate-oval body arose two flagella, the anterior one vibratile, the slightly longer posterior one trailing.

A contractile vesicle was present anterior to the middle of the body. The nucleus could not be detected. Movements oscillatory. Habitat, stagnant water.

Length of body, 15 microns.

Order, POLYMASTIGIDA.
Family, POLYMASTIGIDÆ.

TREPOMONAS Dujardin.

Irregular in form but usually rounded posteriorly, with lateral anterior lobes when seen from a lateral point of view. Flagella two, equal in length, one arising from each lateral border.

TREPOMONAS AGILIS Duj.

Body exceedingly irregular in shape, different appearances being presented from different points of view; when viewed laterally the body is rounded posteriorly, expanding anteriorly into two broad wing-like lateral lobes, which curve backward nearly to the center of the body. Flagella two in number, one arising from the posterior tip of each lateral lobe-like expansion.

Length, 10–20 microns.

This species is one of the smallest of free-swimming Protozoa to be found in this state. Its movements are very rapid and difficulty is often experienced in making a satisfactory study of it in the living condition. The lateral view as described above and illustrated by Fig. 46, Pl. VII, is the one by which the organism is most readily recognized. From other points of view various impressions as to its form are given, and when in rapid motion the body often has the appearance of being spirally twisted.

No oral aperture is visible and probably food may be ingested at any point in the surface.

Found in pond water, widely distributed.

Order, EUGLENIDA.
Family, EUGLENIDÆ.

EUGLENA Ehrenberg.

Body elongate, changeable in form. Endoplasm usually bright

green in color. Flagellum single, inserted in a notch-like excavation on the anterior border. Eye-spot usually present.

EUGLENA VIRIDIS Ehr.

Body usually rounded anteriorly, with a colorless tail-like posterior prolongation, surface smooth. Nucleus central, contractile vesicle and eye-spot in the anterior region.

Length of body, 50-75 microns. (Fig. 51, Pl. VIII.)

This specimen is one of the most common forms of the class to be found in fresh and stagnant waters. That *Euglena viridis* possesses a distinct oral aperture has long been demonstrated and although the organism may depend in part upon the chlorophyl which it usually contains, there is no doubt but that it may at any time ingest organic substances and during periods, when the chlorophyl is lost, may exist entirely upon food obtained in this manner.

There may be periods of more or less duration during which no chlorophyl or pigment spots are present, and at the same time the activity of the organism is not apparently lessened.

That *Euglena viridis* is extremely sensitive to the various forms of stimuli and changing conditions, may be readily observed in the laboratory. The organism is repelled by cold and darkness, attracted by heat and light. A few hours in total darkness has proved sufficient to cause the species to become encysted. Other conditions even in a state of nature frequently cause the chlorophyl to break down into pigments of various colors. Starch-like bodies are often contained within the endoplasm.

Reproduction takes place by longitudinal fission and also by spore formation.

Figure 51, Plate VIII, illustrates a normal individual of the species. Often found on the surface of stagnant water in masses visible to the naked eye. Also found commonly among algæ.

EUGLENA SPIROGYRA Ehr.

Body elongate, cylindrical, posterior extremity terminating in a pointed, tail-like prolongation, endoplasm usually bright green, the periphery covered by oblique rows of minute, bead-like elevations. Nucleus centrally located on either side of which is usually an elongated elliptical starch-like body, contractile vesi-

cle and eye-spot in the anterior region near the base of the flagellum.

Length of body, 100–200 microns. (Fig. 52, Pl. VIII.)

Euglena spirogyra is the largest species of the genus coming under my observation. The body ornamented in a spiral fashion is frequently found in a twisted and contorted condition and the bead-like elevations may be partially or entirely wanting. It is a much more sluggish organism than *Euglena viridis*, the flagellum being comparatively short. Usually found in fresh water among algæ, mostly solitary.

EUGLENA ACUS Ehr.

Body exceedingly elongate, anterior end truncate, posterior end sharply pointed. Flagellum short. Nucleus central, contractile vesicle anterior, pigment spot and amylaceous bodies conspicuous.

Length of body, 75–150 microns. (Fig. 54, Pl. VIII.)

The great length compared with the width and the apparent rigidness of the body may readily distinguish this species from other members of the genus. The organism may exceed in length twelve times its greatest breadth and the body is seldom or never flexed.

Usually the starch-like bodies appear as elongate rectangular structures, one anterior and the other posterior to the nucleus. The flagellum is very short and movement of the animal, when it takes place, is very slow.

Found nearly everywhere in pond water, often abundantly among algæ, etc.

EUGLENA DESES Ehr.

Body elongate, worm-like, capable of amœboid movements. Flagellum short. Nucleus, contractile vesicle and pigment spot present. Amylaceous bodies usually scattered throughout the endoplasm. Color green.

Length of extended body, 50-100 microns. (Fig. 53, Pl. VIII.)

As an organ of locomotion, the flagellum of *Euglena deses* is of little value, movements usually being confined to exceedingly slow amœboid contortions of the body. In young individuals the flagellum may be wanting. The species is usually solitary in its habits, being found not infrequently in fresh water among algæ.

PHACUS Dujardin.

Body flattened, leaf-like, with a tail-like posterior prolongation. Oral opening distinct. Flagellum single, eye-spot present. Color usually green.

PHACUS PLEURONECTES Müll.

Body flattened, oval in outline with a short posterior tail-like projection, usually curved. Surface longitudinally striated. Endoplasm bright green enclosing one or more large circular amylaceous bodies. Nucleus often concealed, contractile vesicle and pigment spot near the base of the flagellum, which arises from the cleft-like oral aperture on the anterior border.

Length, 25–75 microns. (Fig. 55, Pl. VIII.)

This species is widely distributed, being found in great abundance in fresh water among aquatic plants, also often developed in infusions of pond water.

There are apparently several varieties of the species found in this state. Fig. 55, Pl. VIII, illustrates a large variety of this species. Associated with this variety is sometimes found a smaller form possessing two lateral amylaceous bodies, with a deep depression extending from the oral aperture in a median line nearly to the posterior border. This may represent an immature phase of *Phacus pleuronectes*. A yet smaller form has been observed, the endoplasm of which has a decidedly bluish appearance. It is not improbable that this form also is a phase of *Phacus pleuronectes*.

PHACUS LONGICAUDUS Ehr.

Body rounded, flattened, produced posteriorly into a long tapering, tail-like prolongation, usually straight. Endoplasm green, enclosing amylaceous bodies. Surface longitudinally striated.

Length, including tail, 100 microns. (Fig. 56, Pl. VIII.)

Phacus longicaudus is recognized by its large size and long caudal projection which may exceed in length half the diameter of the body. Often the posterior half of the organism is twisted on its longitudinal axis giving the striations of the surface an oblique appearance.

The body may become elongated to nearly twice its usual length although, due to the hardness and consistency of the cuticle, the

process requires a long time. The nucleus, centrally located, is usually concealed. A brilliant red pigment spot is placed near the contractile vesicle.

Figure 56, Plate VIII, illustrates a normal individual of this species. Usually solitary in habits, found widely distributed in fresh water.

PHACUS PYRUM Ehr.

Body pyriform, produced posteriorly into a straight, tail-like prolongation. Surface obliquely grooved. Color green.

Length, 38 microns. (Fig. 57, Pl. VIII.)

This species is often found in great numbers in fresh water associated with *Euglena viridis* and aquatic plants of low rank.

The nucleus is usually concealed. A contractile vesicle and pigment spot are anteriorly located near the base of the flagellum. In motion the body follows a meandering course, rolling on its longitudinal axis.

CHLOROPELTIS Stein.

Oval, sometimes flattened, posterior extremity tail-like, anterior border with a small conical projection. Flagellum single. Endoplasm green. Surface with or without striations.

CHLOROPELTIS OVUM Ehr.

Body oval, cylindrical, with an anterior conical projection from which arises a long flagellum, posterior extremity prolonged into a straight, tail-like process. Endoplasm green, usually enclosing four amylaceous bodies laterally placed. Surface of the body often striated.

Length, 42 microns. (Fig. 58, Pl. VIII.)

Found in fresh water with *Euglena viridis*. Not an abundant form in this state.

CHLOROPELTIS HISPIDULA Eichwald.

Body oval, flattened, with a tail-like projection. Surface of the body ornamented with minute spines arranged in longitudinal rows. Endoplasm green, with eye-spot.

Length, 55 microns. (Fig. 59, Pl. VIII.)

This species is exceedingly rare in the waters of this state, as it has been observed but once and that was in Johnson county. In

this individual the caudal appendage was straight; seven longitudinal ribs were present on either of the flattened surfaces, each rib being thickly set with minute spines which pointed posteriorly. Habitat, fresh water among diatoms.

Besides the two species of *Chloropeltis* already referred to there appears in this state another form which, in my opinion, should be referred to this genus.

The oval body, broadly rounded at each extremity, possesses the characteristic elevation on the anterior border from which arises a long flagellum. A small, conical projection arises from the posterior border. The surface is grooved in an oblique direction. Usually the endoplasm is colored bright green although colorless individuals are not infrequently seen. In these latter the oblique markings are evident. This form is more abundant than *Chloropeltis hispidula* in this state but usually solitary in habits. Habitat, fresh water.

Length, 50–60 microns. (Fig. 60, Pl. VIII.)

TRACHELOMONAS Ehrenberg.

Body inhabiting a hard, brittle lorica usually brownish in color. Flagellum single, protruding through the single aperture. Endoplasm usually green, with nucleus, contractile vesicle and eyespot present.

TRACHELOMONAS PISCATORIS Stokes.

Lorica flask-shaped, cylindrical, less than twice as long as broad, surface clothed by numerous short, conical spines. Both extremities equally rounded, the anterior produced into a smooth, cylindrical, neck-like prolongation, the border of which is deeply toothed.

Length, 36 microns. (Fig. 64, Pl. IX.)

The above description as given by Dr. Stokes well characterizes a form frequently observed in the waters of this state.

Thirty-six microns has been observed by the writer to be the approximate length of the lorica of the mature organism. Its distribution over the state is general. Habitat, fresh water, among aquatic plants.

TRACHELOMONAS CYLINDRICA (?) Ehr.

Lorica very elongate, cylindrical, surface smooth, anterior extremity produced into a short, tubular neck. Color usually brown.

Figure 65, Plate IX, illustrates a form which was observed in the vicinity of Iowa City during the autumn of 1903.

In many respects it differs from the description of *Trachelomonas cylindrica*, as found in Kent's "Manual of The Infusoria." The lorica did not present the flattened appearance of the posterior border and the distal margin of the tubular neck was conspicuously everted.

The lorica was transparent, rendering visible the bright green endoplasm and red pigment spot. Flagellum long. Length of lorica, approximately, 20 microns. Habitat, fresh water.

I refer the form to this species with much doubt as to its true identity. It possibly may have been an undeveloped phase of some other species of the genus.

TRACHELOMONAS ARMATA Stein.

Lorica nearly as broad as long, the surface finely punctate. A series of short, sharp spines arranged in irregular rows about the aperture, and frequently a number of long slender spines, curved when mature, arranged around the posterior extremity. Aperture usually in a shallow depression. Color brown.

Length, 40 microns.

This is the largest species of the genus observed in the state. It has most frequently been found devoid of posterior spines, this condition being, perhaps, a mark of immaturity. The posterior spines when present have, in many forms examined, been long and curved as represented by Fig. 66, Pl. IX. Other individuals observed possessed long, slender, but straight spines. Probably full development had not been reached by these specimens when examined, as Dr. T. C. Palmer reports that the curved spines are late additions in the development of the organism. Usually fourteen or more short, conical spines are arranged about the aperture in two or three irregular rows. These are produced before the posterior spines make their appearance.

The species is widely distributed over the state, having been found in many sections. It is, however, not an abundant species.

Habitat, fresh water with algæ and diatoms.

TRACHELOMONAS HORRIDA Palmer.

"Lorica ovoid, brown, the general surface tuberculate, beset with long, nearly straight, prismatic, abruptly pointed spines,

longer on the ends than on the sides. Aperture plane, or produced into a short trumpet-shaped tube with wavy limb. Monad green, pigment-spot obvious. Flagellum long."

Length of Iowa forms, 35–40 microns. (Fig. 69, Pl. X.)

Dr. T. C. Palmer, of Pennsylvania, whom I have quoted, discovered and described this species. A mature specimen may readily be distinguished from other members of the genus.

It is an extremely rare form in this state, having so far been found but a few times. Dr. Palmer kindly identified specimens collected by the writer during the summer of 1905.

Habitat—Found in Iowa among diatoms and other aquatic plants.

TRACHELOMONAS VOLVOCINA Ehr.

Lorica nearly spherical, usually brown in color, surface nearly smooth, commonly without a neck.

Diameter of lorica of large specimen, 30 microns. (Figs. 67-68, Pl. IX.)

Trachelomonas volvocina is the most common species to be observed in this state. The size and the shape of the lorica varies greatly, the spheroidal variety is, however, more numerous. Sometimes loricæ, evidently of this species, may be found having short cylindrical necks and in some the tube-like neck may extend inward toward the protoplasm of the body. Fig. 68, Pl. IX, represents a common form, probably of this species. Flagellum long.

Habitat, fresh water among diatoms, algæ and other aquatic plants.

TRACHELOMONAS HISPIDA Stein.

Lorica usually elongate-oval with ends broadly rounded. Surface covered with minute, sharp pointed spines. Aperture on a level with the anterior border or truncating a short, tube-like neck. Color, some shade of brown.

This form is widely distributed over the state, being commonly found associated with *Trachelomonas volvocina*. The species may present a variety of shapes; those most frequently observed in this state, however, are as represented by Fig. 70, Pl. X.

Large specimens from the locality of Iowa City have reached a length of from 30–36 microns.

TRACHELOMONAS sp.

Probably a new species.

Lorica ovate, widest and broadly rounded anteriorly, narrow and acutely rounded posteriorly. Surface punctate in a regular manner, the punctæ being arranged in oblique rows in two directions. Aperture plane, a neck never being produced. Flagellum long. Endoplasm usually green. Color of lorica some shade of brown.

Length, 27 microns. (Fig. 71, Pl. X.)

A species, the chief characters of which are given above, has been found in Johnson county, Iowa.

Dr. T. C. Palmer of Media, Pa., whose work upon this particular genus is deserving of no little merit, after examining specimens sent him for identification, considered that the Iowa form was probably a new species. It apparently resembles, in outline, *Trachelomonas reticulata* Klebs, but the recticulate surface has not been made out in the species in this state; on the other hand, the punctæ which cover the surface are arranged with the regularity described above.

Habitat, infusions of pond water among decaying vegetation, being developed in great numbers on the occasions observed.

Distribution has not thus far been found to be general. It is hoped that further observation may reveal a more complete knowledge of the organism.

CRYPTOGLENA Ehr.

Body flattened, persistent in shape. Two lateral, brightly colored pigment bands. Flagellum single. Mouth, eye-spot, nucleus and contractile vesicle usually visible.

CRYPTOGLENA PIGRA Ehrenberg.

Body oval, somewhat flattened, pointed posteriorly. Flagellum single, short. Two bright green pigment bands one on either side following the contour of the body. A scarlet pigment spot near the anterior extremity, nucleus posterior to the center of the body.

Length, 12 microns. (Fig. 83, Pl. XI.)

Cryptoglena pigra is not abundant in this state but may be found associated with *Euglena viridis* in fresh water.

Family, ASTASIIDÆ.

ASTASIA Ehrenberg.

Body elongate, plastic, changeable in form; flagellum single, arising from the anterior extremity; endoplasm transparent.

ASTASIA TRICHOPHORA Ehr.

Body elongate, wider posteriorly, tapering toward the narrow anterior extremity. Flagellum long and thick. Nucleus centrally located; contractile vesicle in the anterior region.

Length of the extended body, 30–60 microns. (Figs. 72-73, Pl. X.)

Astasia trichophora is interesting because it bears evident marks of ancestral characters. The body of the organism is exceedingly plastic, yet progress in development has gone so far as to render the periphery a sufficient resistant to the endoplasm that no pseudopodia are produced. The amœboid changes of form are due to contraction of the peripheral protoplasm, usually in a longitudinal direction.

When freely moving *Astasia* is usually elongate with the narrow extremity in advance, then suddenly it doubles on itself or contracts into an irregular mass, resuming the elongate form again as it continues its course.

At times the posterior border may be prolonged into a short tail-like extension. At the base of the long, thick flagellum is a more or less distinct oral opening which leads into a pharyngeal tube which is highly extensile. No eye-spot or coloring matter is developed, the endoplasm being transparent.

Figure 72, Plate X, represents an elongate form. Fig. 73, Pl. X, a partially contracted individual. *Astasia trichophora* is found almost everywhere in fresh water, commonly occurring among diatoms, algæ, etc.

DISTIGMA Ehrenberg.

Body changeable in form, more or less elongate when extended. Flagella two in number, unequal in length, both directed forward. Oral opening at the base of the flagella leading into a long pharynx. Endoplasm transparent.

DISTIGMA PROTEUS Ehr.

Body exceedingly plastic, when contracted greatly distended

in one or more regions; both flagella vibratile, one equalling the body in length, the other about one-half that length. Endoplasm transparent with dark colored corpuscles, which are shifted about by the movements of the body. Nucleus central, contractile vesicle in the anterior region.

Length of the extended body, 95 microns.

Figure 74, Plate X, illustrates the species as it commonly appears in a mature condition and extended. Fig. 75 represents the partially contracted state.

The species is not uncommon in pond water.

Family, PERANEMIDÆ.

HETERONEMA Dujardin.

Body oval or elongated, changeable in shape. Flagella two in number, one directed forward, one trailing, both arising from the anterior extremity. Oral aperture near the base of the flagella.

HETERONEMA ACUS Ehr.

Body greatly elongated when extended, wider centrally, tapering toward each extremity. Anterior flagellum about as long as the body and twice as long as the trailing one. Contractile vesicle in the anterior extremity, nucleus centrally located.

Length, when extended, 50 microns. (Fig. 76, Pl. X.)

Heteronema acus is exceedingly plastic and changeable in form, becoming shortened and greatly distended on contraction. The long anterior flagellum is not highly vibratile. Found in fresh water in Johnson and Keokuk counties.

PETALOMONAS Stein.

Somewhat oval, flattened, and of hardened consistence. Flagellum single. Oral aperture distinct.

PETALOMONAS MEDIOCANELLATA Stein.

Body ovate, flattened, persistent in shape, broadly rounded posteriorly, tapering to an acutely pointed anterior extremity. Flagellum single, arising from the anterior extremity and directed in advance of the body, a distinct groove leading from the base of the flagellum posteriorly.

Length of the body, 30-40 microns. (Fig. 77, Pl. XI.)

Petalomonas mediocanellata is to be found frequently in fresh water among aquatic plants. Its movement is smooth and gliding, the tip of the long flagellum being vibratile. Due to the groove in the median line of the body food particles are conducted to the posterior region where digestion takes place. It is in this region that the spherical nucleus is to be found. The contractile vesicle is lateral to the oral groove in the anterior region, which is comparatively free from granular particles.

ANISONEMA Dujardin.

Body ovate, flattened, persistent in form. Oral aperture leading into a long pharynx. Flagella two in number, the vibratile one arising from the ventral border, and directed forward, the posterior one long, arising posterior to the vibratile one and curving backward in a trailing manner. Contractile vesicle or vesicles anterior, nucleus posterior.

ANISONEMA ACINUS Duj.

Body with ventral surface flattened, wider posteriorly, the anterior flagellum short, vibratile, the posterior one with a thickened base, long, trailing. Oral opening near the base of the anterior flagellum. Endoplasm transparent, contractile vesicle and nucleus conspicuous.

Length, 25 microns. (Fig. 78, Pl. XI.)

This species of the genus is widely distributed, being found nearly everywhere in pond water, among diatoms and other aquatic plants. Its movement is usually forward in a straight line, the trailing flagellum serving as a rudder directing the course. Reproduction takes place by longitudinal division.

ANISONEMA LUDIBUNDUM S. K.

Body nearly oval, narrower at the anterior extremity. Flagella two in number, about twice the length of the body, inserted at some distance from the anterior end. Contractile vesicles often more than one.

Length, 10 microns. (Fig. 79, Pl. XI.)

This smallest species of the genus has come under my observation but a few times. By means of the posterior flagellum the organism may temporarily attach itself. Progress is made by short oscillating movements.

The point of insertion of the flagella will aid in the recognition of this minute form. Habitat, fresh water.

ANISONEMA TRUNCATUM Stein.

Body elongate-ovate, posterior extremity narrowest, anterior border with a shallow concavity at the bottom of which is the oral aperture. Flagella two, the anterior vibratile one about one-half as long as the posterior trailing one. Contractile vesicle anterior.

Length, 30 microns. (Fig. 80, Pl. XI.)

A rare form in this state. Observed only in Johnson county. Habitat, pond water.

ENTOSIPHON, Stein.

Oval, somewhat flattened, and of a hardened consistence. Oral aperture in the anterior border, followed by an elongated tube-like pharynx. Flagella two in number, arising on the anterior border.

ENTOSIPHON SULCATUS Duj.

Body oval, flattened, the anterior border oblique with a deep concavity, at the bottom of which is the oral opening leading into a long tubular pharynx which reaches into the posterior region of the body. Surface of the body grooved longitudinally. Flagella two in number, arising from the anterior border near the oral opening, one long, tralling, the other shorter, directed in advance, vibratile. Nucleus spherical, in the posterior region, contractile vesicle anterior. Endoplasm transparent.

Length of body, 22 microns. (Fig. 81, Pl. XI.)

The long cone-shaped pharynx of this species is very conspicuous. At times it may be partially exserted and owing to its indurated character persists for a long time after the death and decomposition of the organism.

Frequently found in pond water among aquatic plants. Movements oscillating.

Family, NOTOSOLENIDÆ.

NOTOSOLENUS Stokes.

Somewhat oval and flattened, ventral surface convex, dorsal surface concave. Flagella two, the anterior, long one held obliquely, the posterior trailing one very short.

NOTOSOLENUS OPOCAMPTUS Stokes.

Body ovate, the anterior border acutely rounded, the posterior truncate. Flagella two in number, unequal in size and length, the longer projecting obliquely in advance, the shorter trailing.

Length of body, 12 microns. (Fig. 82, Pl. XI.)

Members of this genus may be recognized at once by the oblique manner in which the anterior flagellum is held as the animal moves in a direct course. In *Notosolenus opocamptus* the shorter and smaller flagellum has its origin on the ventral surface near the base of the anterior one and is directed backward hardly one-half the length of the body. It appears as a minute white line on the background of the body. Frequently found in fresh water among aquatic plants. Its distribution over the state is general.

Order, PHYTOFLAGELLIDA.
Family, CHRYSOMONADIDÆ.

NEPHROSELMIS Stein.

Somewhat oval, ventral border concave. Bright colored pigment bands near the periphery. Flagella two in number, of unequal length.

NEPHROSELMIS OLIVACEA Stein.

Body rounded dorsally, slightly concave ventrally, pigment bands following the dorsal and lateral contours of the body. Flagella two, unequal in length, arising from the ventral concave surface. Nucleus in posterior region.

Length, 10 microns. (Fig. 84, Pl. XI.)

This species is a very rare form, having been found in this state but a few times. Its habitat is pond water among aquatic plants.

MALLOMONAS Perty.

Body oval, persistent in shape, surface covered with long, rigid setæ. Flagellum single, inserted at the anterior extremity. Endoplasm often colored.

MALLOMONAS sp.

Figure 85, Plate XI, illustrates a species which rarely may be found in this state. There is no question but that it must be

referred to this genus, but the specific identification is uncertain, largely due to an incomplete study of the organism.

The oval body, narrower at the anterior extremity, was thickly clothed with long, apparently rigid, hair-like setæ. In general appearances the form resembled *Mallomonas Plosslii* Perty. A magnification of five hundred diameters, however, did not reveal the crenulation of the surface which is a character of the last named species. Whether the long flagellum, directed in advance, possessed the retractile power or not I cannot state. One or more contractile vesicles were evident but the nucleus could not be distinguished.

Movement, rapid in a direct course. Color, yellowish brown. Habitat, pond water.

According to Kent the rigid hair-like structures which cover the surface are attached to the hardened cuticle and have no direct connection with the inner endoplasm.

Length of the body as observed, 15-30 microns.

Family, CRYPTOMONADIDÆ.

CHILOMONAS Stein.

Elongate-oval, anterior border with a projecting upper-lip. Flagella two in number, nearly equal, both directed in advance. Oral aperture on the anterior border near the base of the flagella.

CHILOMONAS PARAMÆCIUM Ehr.

Body elongate-oval in shape, usually rounded posteriorly, anterior margin with a prominent lip-like projection. Flagella two in number, sub-equal in length, arising from the lip-like extension, both directed forward, oral opening near the base of the flagella. Nucleus central, contractile vesicle anterior. Endoplasm usually enclosing dark-colored corpuscles.

Length of body, 25-40 microns. (Fig. 86, Pl. XI.)

Chilomonas paramæcium is one of the most common flagellates of stagnant infusions. The flagella are delicate and difficult to see during the activity of the organism. The lower one being slightly shorter is often thrown into a coil and serves as an anchor to temporarily attach the organism to some support. In progression the animal takes a zigzag, roving course, rolling on its longitudinal axis.

Reproduction takes place by longitudinal division with great rapidity. Two other flagella are first developed from the anterior border, then a longitudinal constriction is seen to take place and the two portions of the organism seem to be rapidly drawn apart.

Widely distributed, everywhere in stagnant water.

CRYPTOMONAS Ehrenberg.

Body ovate, with a prominent anterior lip-like process. Flagella two in number, nearly equal in length, directed forward, oral aperture at the base of the flagella. Endoplasm containing color bands disposed in a longitudinal manner. Contractile vesicle anterior, nucleus near the middle of the body.

CRYPTOMONAS OVATA Ehr.

In size and appearance, except for the coloring matter, *Cryptomonas ovata* resembles *Chilomonas paramœcium*. The lip-like process is very prominent, beneath which is a spacious buccal cavity leading posteriorly into the endoplasm, the oral aperture at times being widely distended. The species as found in this state invariably possesses two broad, lateral, chlorophyl bands extending from the posterior to the anterior extremity, one on either side of the body. Its common habitat is fresh water with other chlorophyl-bearing flagellates. Widely distributed.

Length of body, 50 microns. (Fig. 87, Pl. XI.)

Family, CHLAMYDOMONADIDÆ.

CHLAMYDOMONAS Ehrenberg.

Enclosed within a membranous, transparent sheath. Body oval or spherical. Flagella two in number. Endoplasm green with an eye-spot, nucleus, contractile vesicles, chromataphores and starch-like bodies.

CHLAMYDOMONAS sp. (?).

Lorica transparent, somewhat truncate anteriorly, narrower and rounded posteriorly. Body green, filling little more than half the lorica; flagella two in number, of equal length. A pigment-spot usually present.

Length of lorica, 12 microns. (Fig. 61, Pl. IX.)

This species is not an abundant form in this state. It has frequently been found in pond water in Johnson county, but apparently is not of wide distribution.

CHLAMYDOMONAS sp.

Lorica transparent, elongate-oval, rounded anteriorly, often acutely pointed posteriorly. Body usually green, almost completely filling the lorica. Flagella two in number, of equal length. A contractile vesicle and pigment spot near the base of the flagella, nucleus central.

Length of lorica, 15-20 microns. (Figs. 62-63, Pl. IX.)

This species which I have referred to the genus *Chlamydomonas* differs materially from the one previously described both in the shape of the lorica and the comparative size of the body. In some respects it resembles *Chlamydomonas ovata* Dangeard, and may be identical with that species. It was first observed in an infusion of moss in the locality of Iowa City, during May, 1905. At that time the classification was puzzling, possessing as it did the generic characters of *Chlamydomonas*, but during the two or three weeks it was under my observation, no chlorophyl was present; the organism was transparent, slightly granular.

It was my good fortune, however, to find the same species during the month of July, 1905, in pond water in Appanoose county. The organisms from this locality left no question as to the genus to which they belonged and convinced me that the forms earlier found were in a saprophytic stage. In the same infusion appeared individuals bright green in color with brilliant eye-spots, also perfectly transparent forms with no eye-spots, while others represented intermediate phases between these two extremes. The transition from the saprophytic to the chlorophyl-bearing stage was readily observed. In the immature individuals the lorica is not easily distinguished from the body, which is usually in close contact with its transparent, investing membrane. In mature specimens, however, the lorica extends beyond the posterior region of the body, either with a rounded border or drawn out into an acute point. The lateral and anterior borders of the body may often be drawn away from the lorica, leaving it visible as a delicate line.

Reproduction usually takes place by means of segmentation of

the entire body, the organism dividing into four, then into eight small zoöids, which break through the lorica and begin an independent existence. As a result of the rapid reproduction myriads of individuals may be developed in a short time. One or two small contractile vesicles may be observed near the base of the long flagella, also a brilliant red eye-spot. A centrally located nucleus is rendered visible by reagents.

On one occasion longitudinal division was observed to take place. The species has been found in this state only in the two localities named above. Habitat, pond water among decaying vegetation, or damp moss from the base of trees.

TABLE OF CLASSIFICATION.

Class, INFUSORIA.

Protozoa with cilia during embryonic and adult life or embryonic only.

Sub-class, CILIATA.

With cilia during entire existence.

Sub-class, SUCTORIA.

With cilia during embryonic life only, with suctorial or piercing tentacles during adult life.

ORDERS OF CILIATA.

HOLOTRICHA.

Cilia usually covering the entire body, sometimes slightly longer about the oral aperture. Trichocysts often present.

HETEROTRICHA.

Body entirely ciliate, cilia of the oral region longer than those of the general surface and often fused together.

HYPOTRICHA.

Usually flattened with cilia confined to the ventral surface.

PERITRICHA.

Cilia reduced to one or two wreaths or circles.

NOTE.—In some classifications Suctoria is considered as an order, here, however, being used as a sub-class, no order names are given.

Families and Genera of Holotricha.

Enchelinidæ.

Mouth terminal or sub-terminal. Food ingested by swallowing.

Coleps Ehr.
Holophrya C. & L.
Urotricha C. & L.
Enchelyodon C. & L.
Prorodon Ehr.
Trachelophyllum C. & L.
Didinium Stein.
Mesodinium Stein.
Lacrymaria Ehr.

Trachelinidæ.

Body usually bilateral with dorsal surface convex. Mouth terminal or sub-terminal. A neck-like region often present.

Loxophyllum Duj.
Amphileptus Stein.
Dileptus Duj.
Lionotus Wrzes.
Loxodes Ehr.
Trachelius Ehr.

Chlamydodontidæ.

Oval or kidney-shaped. Pharynx distinct, often provided with rods.

Nassula Ehr.
Chilodon Ehr.
Ægyria C. & L.
**Opisthodon* Stein.

Oval, convex dorsally, flattened ventrally. Mouth in posterior half of body. Pharynx with rods.

Chiliferidæ

Mouth anterior or central, usually with an undulating membrane. Pharynx short or absent.

Trichoda Müll.
Leucophrys Ehr.
Glaucoma Ehr.

Frontonia Ehr.
Ophryoglena Ehr.
Loxocephalus Eberh.
Uronema Duj.
Colpidium Stein.
Colpoda Müll.
**Dallasia* Stokes.

Elongated, rounded anteriorly, tail-like posteriorly. Mouth near the anterior end with membranes similar to *Glaucoma*.

UROCENTRIDÆ.

Mouth ventral. Cilia in two broad bands encircling the body.
Urocentrum Nitzsch.

MICROTHORACIDÆ.

Cilia scattered, mouth in the posterior region.
Microthorax Eng.
Cinetochilum Perty.

PARAMÆCIIDÆ.

Mouth lateral, preceded by an oblique oral groove.
Paramœcium Müll.

PLEURONEMIDÆ.

Mouth at the posterior end of a ventral furrow or peristome. Peristome with undulating membrane or membranes.
Lembadion Perty.
Cyclidium Ehr.
Ctedoctema Stokes.
**Pleuronema* Duj.
Slightly larger than *Cyclidium*. No posterior setæ.

CYRTOLOPHOSIIDÆ.

Body at times enclosed within a soft mucilaginous envelope secreted by itself. Mouth at the end of a short furrow. A tuft of cilia at the anterior extremity.
Cyrtolophosis Stokes.

FAMILIES AND GENERA OF HETEROTRICHA.

PLAGIOTOMIDÆ.

Mouth near or posterior to the middle of the body, preceded by a narrow peristomal furrow.

Blepharisma Perty.
Metopus C. & L.
Metopides Quenn.
Spirostomum Ehr.

BURSARIDÆ.

Peristome a broad, triangular depression, sometimes with a conspicuous undulating membrane.

Condylostoma Duj.
**Bursaria* Müll.

Body short, sac-like, obliquely truncate in front, flattened ventrally, convex dorsally. Peristome funnel-shaped, reaching to the middle of the body.

STENTORIDÆ.

Peristome occupying the front border. Mouth in the margin of the peristome, with strong adoral cilia spirally disposed. Body entirely ciliate.

Stentor Oken.

GYROCORIDÆ.

Oval or pear-shaped, with one or two spiral wreaths of strong cilia. A style-like posterior process often present.

Gyrocoris Stein.

HALTERIIDÆ.

Body with an anterior ring of cilia. Sometimes a posterior circle is also present or an equatorial wreath of springing hairs.

Halteria Duj.
**Strombidium* C. & L.

Similar to *Halteria* but without springing hairs. Oral cilia very strong.

FAMILIES AND GENERA OF HYPOTRICHA.

OXYTRICHIDÆ.

Cilia of the ventral surface usually fused into styles or setæ arranged in series, as frontal, ventral, anal, caudal, and marginal. One or more of these series may be wanting.

Urostyla Ehr.

Stichotricha Perty.
Uroleptus Ehr.
Pleurotricha Stein.
Gastrostyla Eng.
Oxytricha Ehr.
Histrio Sterki.
Stylonychia Ehr.
**Holosticha* Wrzes.

Differing from *Oxytricha* in possessing two uninterrupted rows of ventral setæ.

**Urosoma* Kowal.

Resembling *Oxytricha*, but with eight ventral setæ and with a tail-like projection.

EUPLOTIDÆ.

Oval, dorsal surface convex. Anal styles usually well developed but those of other series often reduced in number. Marginal series seldom present.

Euplotes Ehr.
Aspidisca Ehr.

FAMILIES AND GENERA OF PERITRICHA.

NOTE.—Practically all fresh water forms of this order may be included within one family.

VORTICELLIDÆ.

Bodies frequently bell-shaped. Front border bearing a spirally wound wreath of strong cilia; a posterior circle of cilia sometimes developed; otherwise the body is free from cilia. Animals attached or free-swimming, often forming colonies and inhabiting loricæ.

Gerda C. & L.
Scyphidia Duj.
Vorticella Linn.
Carchesium Ehr.
Epistylis Ehr.
Vaginicola Lamarck.
Cothurnia Ehr.
**Zoothamnium* Ehr.

Similar to *Carchesium* but with continuous muscle fibre. The entire colony is highly contractile.

**Rhabdostyla* S. K.

Similar to *Vorticella* but attached by a short rigid stalk. Never forming colonies.

**Pyxidium* S. K.

Animals similar to *Opercularia* but solitary on short rigid stalks.

**Opercularia* Stein.

Forming colonies with a branched but rigid stalk. Animals elongate-oval. Ciliary disc attached by one side and opening and closing like a lid. A delicate collar-like membrane also protruded when the disc is elevated.

Families and Genera of Suctoria.

Podophryidæ.

Spherical or elongate, with or without a stalk. Tentacles scattered or in groups, capitate and suctorial or prehensile.

Sphærophrya C. & L.

Podophrya Ehr.

Acinetidæ.

With or without a lorica, stalked or unstalked. Tentacles usually capitate and in groups or scattered.

Acineta Ehr.

Hallezia Sand.

**Solenophrya* C. & L.

Body oval, enclosed by a lorica and attached in a sessile manner. Tentacles capitate, in groups.

Dendrosomidæ.

Without a stalk or lorica. Tentacles capitate, in groups.

Trichophrya C. & L.

**Dendrosoma* Ehr.

Animals united, forming a branched colony with a common base. Tentacles suctorial, capitate.

Note.—In the above table of classification only families, representatives of which have been observed in this state, are included. Species of genera marked with the asterisk (*) have not, so far, been observed in the state.

Class, INFUSORIA.
Sub-class, CILIATA.
Order, HOLOTRICHA.
Family, ENCHELINIDÆ.

COLEPS Ehrenberg.

Ovate, persistent in shape. Surface usually deeply furrowed longitudinally and transversely, the furrows bearing cilia. Oral aperture terminal, surrounded by cilia larger than those of the general surface. Posterior border often bearing spines.

COLEPS HIRTUS Ehr.

Body barrel-shaped, elongate, cylindrical. Mouth terminal, bordered by tooth-like processes. Posterior border rounded, with three spines. General surface furrowed at right angles giving the appearance of small rectangular, raised areas which are indurated.

Nucleus large, spherical, in the central or posterior region. Contractile vesicle posterior.

Length, 60 microns. (Fig. 88, Pl. XII.)

Coleps hirtus is a very common species in pond water and old infusions. The organism usually appears late in the infusion, after most of the other forms have disappeared, being a scavenger feeding upon decaying matter. Should another infusorian, as *Paramæcium*, die, a group of these organisms gather about the dead protoplasm, devouring it rapidly and greedily. The mouth is capable of wide extension during feeding and the body may become nearly spherical, due to ingested material.

Reproduction takes place by transverse fission, an interesting feature presenting itself in this connection. The constriction of the body commences with the middle transverse furrow, the opposite extremities of the dividing cell retaining the reticulate appearance, but the newly developed central area bears no furrows. Even after complete separation one-half of each new individual, bearing the reticular area, is sharply contrasted with the smooth unfurrowed region. After a period of more or less duration the smooth half begins to take on the furrowed appearance and finally reaches the same proportions as the opposite portion.

HOLOPHRYA Ehrenberg.

Ovate or elongate, changeable in form. Oral opening in anterior border, terminal. Cilia of entire body of uniform size.

HOLOPHRYA KESSLERII Meresch.

Body elongate, cylindrical, posterior border rounded, anterior border truncate. Surface furrowed longitudinally. Nucleus elongate, band-like, centrally located. Contractile vesicle posterior.

Length when extended, 125 microns. (Fig. 89, Pl. XII.)

A rare form in this state. It has been found in fresh water in Johnson county among algæ. Solitary in its habits. Movement rapid, by turning on its longitudinal axis. On contraction the longitudinal striations do not become oblique as in case of *Holophrya tarda*, a closely allied form.

UROTRICHA C. & L.

Oval or elliptical. Cilia not moving in unison. Oral aperture at the anterior extremity, terminal. A long seta used as a springing hair, developed from the posterior extremity. Contractile vesicle and nucleus usually conspicuous.

UROTRICHA PLATYSTOMA Stokes.

Body ovate, a little longer than broad, equally rounded at both extremities. Cilia covering the entire body, vibrating independently. Surface covered with minute, round, bead-like elevations arranged in longitudidal series. Mouth capable of very wide expansion. Springing hair shorter than the body, pointing obliquely, with the distal end curved.

Length of body, 40 microns. (Fig. 90, Pl. XII.)

Urotricha platystoma reproduces by transverse division. Movement is by rotation on its longitudinal axis, frequently darting to one side by means of the posterior springing hair, not unlike *Halteria*.

The form has often been found in fresh water in this state.

UROTRICHA sp.

Body ovate, wider anteriorly, more acutely rounded posteriorly. Surface smooth. Movement of cilia very irregular and independent. Oral aperture apical, terminal, provided with two lip-like extensions of unequal length. Springing hair short, less than

half the length of the body, straight. Nucleus central. Contractile vesicle posterior.

Length of body, 35 microns. (Fig. 91, Pl. XII.)

This species of *Urotricha* has been found in Johnson county, associated with *Cyclidium glaucoma*.

It differs from *Urotricha lagenula* Ehr. (not observed in this state) in the inflation of the anterior region and the short length of the springing hair. The oral opening has two protruding lip-like processes and is capable of very wide expansion during the process of ingestion of food. Its breadth when expanded may almost equal the greatest width of the body. When closed the lip-like protrusions meet, one, however, being decidedly shorter than the other. The organism has the habit of a scavenger, dead protoplasm serving as its chief food.

A central spherical nucleus may be observed by the aid of reagents and a single contractile vesicle is present in the posterior region.

In its movement the species usually rotates on its longitudinal axis, the springing action not being so noticeable as in *Urotricha platystoma*,

Reproduction takes place by transverse fission.

ENCHELYODON C. & L.

Body ovate, rounded posteriorly, narrower anteriorly but not produced into a neck-like extension. Oral aperture terminal, followed by a pharynx which is striated in a longitudinal direction.

ENCHELYODON FARCTUS C. & L.

Body oval, narrower anteriorly and often slightly curved. Pharynx conspicuous and can be traced for some distance within the endoplasm. Nucleus band-like, long and curved. Contractile vesicle posterior. Endoplasm transparent.

Length, 220 microns. (Fig. 92, Pl. XII.)

Enchelyodon farctus has been found abundantly in Johnson county in infusions of pond water.

Reproduction is by transverse fission.

PRORODON Ehrenberg.

Usually oval, sometimes slightly flattened, evenly rounded at both extremities. Mouth terminal or sub-terminal; pharynx

often with rod-like teeth. Nucleus oval or band-like. Cilia covering the entire body, sometimes longer on the posterior border.

PRORODON TERES Ehr.

Body oval, cylindrical. Oral opening terminal, provided with minute, rod-like teeth. Nucleus spherical, centrally located; contractile vesicle in the posterior region.

Length, 150–200 microns. (Fig. 93, Pl. XII.)

This species has frequently been found in stagnant pond water. An interesting phenomenon has come under observation with reference to the division of *Prorodon teres* which takes place by transverse fission. A large individual was discovered already in the process of division, which continued until merely a narrow isthmus of protoplasm connected the two portions. Suddenly another constriction began to take place and in a few minutes a very small individual separated from the anterior extremity of the dividing organism and swam away.

In the meantime the original constriction grew deeper and deeper until but a mere thread, seemingly ready to break at any moment, remained. But division was not to take place. All at once there was a rush of endoplasm centrally from each extremity, the narrow connecting thread of protoplasm became inflated and continued to broaden until the body reached its normal proportions.

This, apparently, is a case of defeated division. Probably the small individual carried away with it the entire nucleus of the anterior half, leaving only one nuclear mass for the two dividing portions.

PRORODON EDENTATUS C. & L.

Body oval, cylindrical, equally rounded at both extremities. Oral aperture eccentric, opening into a conical tube which reaches far into the endoplasm. Cilia of the posterior border somewhat longer than those of the general surface. Nucleus spherical, central in position. Contractile vesicle posterior.

Length, 125 microns. (Fig. 94, Pl. XII.)

In general appearance this species resembles *Prorodon teres* but differs from it chiefly in the eccentricity of the mouth.

Although not common, *Prorodon edentatus* may be found in pond water and stagnant infusions.

Reproduction is by transverse fission.

TRACHELOPHYLLUM C. & L.

Elongate, flask-shaped, flattened. Anterior region narrow, neck-like, terminating in a minute conical process which is punctured by the oral aperture.

The pharynx may be traced backwards through the neck-like region. Nuclei usually more than one. Contractile vesicle posterior.

TRACHELOPHYLLUM TACHYBLASTUM Stokes.

Body elongated, flexible, somewhat clavate when fully extended, flask-shaped when contracted. Oral aperture followed by an indistinct pharyngeal passage. Cilia clothing the entire surface and vibrating in an independent manner. Nuclei two in number, spherical, not connected. Contractile vesicle in the posterior region.

Length, 175 microns. (Fig. 95, Pl. XII.)

This species is not uncommonly found in this state although it has not so far been observed to be widely distributed. Found at the bottom of old infusions of pond water, where it glides along evenly and at a rapid rate. Another form, differing from the above apparently chiefly in size, has been found in pond water in Johnson county. Some individuals have exceeded 300 microns in length. It may be identical with *Trachelophyllum vestitum* Stokes, but the external granular covering has not been apparent in the Iowa species.

DIDINIUM Stein.

Usually ovate, cylindrical, rounded posteriorly, produced anteriorly into a short conical proboscis, and bearing a posterior and anterior circle of cilia. Oral aperture puncturing the extremity of the proboscis.

DIDINIUM NASUTUM Müll.

Body oval, broadly rounded posteriorly. Anterior conical proboscis longitudinally striate. One wreath of cilia near the base of the proboscis, the other posterior to the middle of the body.

Nucleus band-like, curved, centrally located. Contractile vesicle posterior.

Length, 100–175 microns.

Figure 96, Plate XIII, represents a typical individual of this species. In its motion *Didinium nasutum* is swift, rolling on its longitudinal axis, darting from side to side, then suddenly stopping in its flight, with the anterior end downward, it whirls rapidly for a few seconds, then continues its random course.

The food habits of *Didinium nasutum* present some interesting features, the organism being found associated with *Paramœcium*, which serves as its principal food. It is fierce and aggressive, grasping its prey with the snout-like proboscis and literally gulping it down whole, the process requiring but a few seconds.

Balbiani, the French naturalist, records that the proboscis may be protruded even to the length of the body and by this means *Didinium* grasps its prey and sucks the contents or transfers it whole to its own body by the retraction of the proboscis. My observations have not verified this; in fact, at no time in the scores and scores of instances in which *Paramœcium* has been observed to become the prey of *Didinium*, was there a protrusion of the snout-like process, but the animal approached and, striking its prey with the unextended proboscis, proceeded to swallow it whole. The striking results in a paralyzing effect upon *Paramœcium*, its struggles ceasing almost immediately.

Sometimes *Paramœcium* is grasped near the middle instead of at the end, in which case *Didinium*, instead of entirely releasing its prey, by a quick, jerky movement shuffles along until one extremity of the "slipper-animalcule" is reached, then the ingestion takes place.

Figure 97, Plate XIII, is drawn from a mounted specimen fixed during the process of ingestion of *Paramœcium*.

Reproduction takes place by transverse fission, preliminary steps to constriction of the body being the elongation of the nucleus and the appearance of two supplementary wreaths of cilia.

A very definite flow of protoplasm within the body may be observed, the endoplasm flowing toward the anterior extremity along the periphery, then turning inward and uniting in a common backward stream along the longitudinal axis, separating in the posterior region, turning outward and flowing forward again.

This protoplasmic current, illustrated by Figure 98, Plate XIII, no doubt is of assistance in the rapid ingestion of food.

Didinium nasutum has been found in but two, though widely distant, regions of the state. In January, 1904, the species was taken from a small stream near Iowa City in an infusion of submerged leaves, and in August, 1905, it was found in Lake Okoboji among decaying vegetation.

MESODINIUM Stein.

Ovate or pyriform, rounded posteriorly, produced into a conical proboscis anteriorly. Oral aperture terminal, puncturing the extremity of the proboscis, at the base of which is a single circle of strong cilia.

MESODINIUM sp. (?)

Figure 99, Plate XIII, represents a species not infrequently found in the fresh waters of this state, which is conditionally referred to this genus.

Body somewhat globose, nearly as broad as long, broadly rounded posteriorly, produced into a snout-like process anteriorly. Oral aperture indistinct but apparently in the distal extremity of the proboscis. Color, green. Nucleus and contractile vesicle concealed.

Length, 35 microns.

The anterior, snout-like proboscis, which has been observed to be somewhat extensile and contractile and which is apparently punctured at its distal extremity by the oral aperture, has led me to conditionally classify the organism here. Future observations may reveal its true identity. So far as I am able to discover, no species of this genus has been reported to be densely green in color, as this organism is.

LACRYMARIA Ehrenberg.

Elongate-oval or flask-shaped, nearly cylindrical, somewhat elastic. Anterior extremity usually very narrow, neck-like and sometimes highly extensile and contractile. Oral aperture terminal, puncturing a cone-like projection, or an obliquely truncate border.

LACRYMARIA COHNII (?) S. K.

Figure 100, Plate XIII, represents a species not infrequently

found in the waters of this state which has been tentatively referred to this species. Body elongate-oval, about two and one-half times as long as broad, highly elastic. Anterior extremity continued as a short, neck-like extension. Oral aperture terminating a cone-like projection which is smaller than the neck and slightly constricted from it. The anterior extremity of the neck bearing a circle of cilia larger than those of the general surface.

Endoplasm completely filled with dark globular masses, rendering the body opaque and concealing the nucleus. Contractile vesicle posterior.

Length of body, 90 microns.

Lacrymaria cohnii is reported to be a salt-water form but the species occurring in this state is so closely allied to it that I would, at least for the time being, classify it here. The species has been found in Lake Okoboji and also in some of the eastern counties of this state. Its habitat is fresh water among aquatic plants. Movement is accompanied by rapid revolution on its longitudinal axis.

LACRYMARIA TRUNCATA Stokes.

Body elongate, somewhat flask-shaped, flattened. Rounded posteriorly, produced anteriorly into a long neck-like region, the anterior border of which is obliquely truncated and slightly dilated. Surface longitudinally striate. Cilia of the anterior extremity slightly larger than those of the general surface. Oral aperture in the anterior truncated border. Nucleus long, band-like, twisted and convoluted in the posterior region. Contractile vesicle posterior.

Length, 160 microns. (Fig. 101, Pl. XIII.)

This species may be found in long-standing infusions of pond water, the truncated anterior border and greatly convoluted nucleus serving to readily distinguish it. The organism is a rapid swimmer, rotating on its longitudinal axis.

LACRYMARIA OLOR Müll.

Body elongate-ovate, posterior extremity pointed. Anterior extensile neck capable of being extended many times the length of the body. Surface obliquely striate in two directions. Nucleus double, central. Contractile vesicles more than one.

Length, with neck contracted, 50–70 microns. (Fig. 104, Pl. XIII.)

A common and widely distributed species found in pond water. Its swan-like appearance was suggested to the early observers by its graceful movements, as it swims about extending its neck here and there in search of food.

Reproduction takes place by transverse fission.

Family, TRACHELINIDÆ.

AMPHILEPTUS Ehrenberg.

Elongate, usually flattened, with an anterior neck-like region at the base of which is the oral aperture. Nuclei usually more than one. Contractile vesicles single or numerous. Trichocysts sometimes present.

AMPHILEPTUS MELEAGRIS Ehr.

Body elongate, compressed, with a short, thick, neck-like anterior region. Mouth, a cleft-like opening near the center of the body. Nuclei, two in number, central in position. Contractile vesicles numerous. No trichocysts.

Length of body, 250 microns. (Fig. 105, Pl. XIV.)

Amphileptus meleagris has been found in pond water, also in running streams, although not an abundant species in this state. An interesting phenomenon with reference to the life history of this organism has been reported by various observers. After feeding upon a zoöid of *Epistylis* or some related species, *Amphileptus* may attach itself to the branch occupied by its victim and there become encysted, during which period division into four animalcules takes place.—Kent, "Manual of the Infusoria." Vol. II, p. 526.

A curious relation between this species and *Carchesium polypinum* which bears witness of the above phenomenon has come under my observation. During September, 1905, on examining *Carchesium polypinum* taken from a small running stream near Iowa City, numerous individuals of the species under consideration were found attached to the branches of the peritrichous colony. The posterior border of *Amphileptus* was deeply cleft and clasped the branch of its host; in addition a protoplasmic band from one of the lip-like processes passed around the branch of *Carchesium*, thereby producing a firm anchorage.

The nuclei were four in number, and of great size, occupying the greater portion of one side of the organism.

This relation, as illustrated by Fig. 102, Pl. XIII, is probably preliminary to the encystment of *Amphileptus meleagris*.

LOXOPHYLLUM Dujardin.

Flattened, leaf-like and flexible, the anterior extremity usually the narrower. Oral aperture on the left border anterior to the middle of the body. Cilia fine, in longitudinal rows. Nucleus differing in different species but often moniliform. Contractile vesicles single or multiple. Trichocysts usually present.

LOXOPHYLLUM sp. (?)

Body very elastic, central region the wider, narrowing toward each extremity. Nucleus in maturity consisting of numerous separate oval masses. Contractile vesicles numerous, scattered. Trichocysts not evident.

Length of body, 400 microns. (Fig. 103, Pl. XIII.)

The organism as described above resembles, in the character of its nucleus, *Loxophyllum meleagris* Müll. The nucleus in some individuals has been observed to be band-like while in other specimens as many as eight disconnected oval bodies are present, the latter probably representing the mature phase of the organism. Crenulation of the dorsal border has, however, not been made out in the Iowa species, nor has the presence of trichocysts been evident.

Found in the bacteria-laden film of water at the surface of pond water infusions.

Reproduction is by transverse fission.

DILEPTUS Dujardin.

Very elongate, with a narrow anterior region, neck-like and flexible, at the base of which is the mouth. Nucleus moniliform. Contractile vesicles numerous, in a dorsal row. Trichocysts present in the neck-like region.

DILEPTUS GIGAS C. & L.

Body greatly elongate, somewhat compressed, often with a pointed tail-like prolongation. Anteriorly the body is produced into a long, flattened, neck-like region, very flexible and slightly

extensile. Oral aperture at the base of the neck, often a prominent hump or shoulder indicating its position. Pharynx short.

Nucleus moniliform, extending nearly the length of one side of the body. Contractile vesicles numerous, arranged in a dorsal row nearly the whole length of the body.

Trichocysts on the ventral surface of the neck.

Length of body, 500-800 microns. (Fig. 106, Pl. XIV.)

This species is one of the most elongated free-swimming species of Protozoa common to this state. The organism is carnivorous in its food habits, smaller animalcules usually being captured by means of the trichocysts and pressed into the oral aperture by the long flexible neck. It has been my observation that the trichocysts are paralyzing in their effect upon the Infusoria, but do not necessarily produce death. *Dileptus gigas* has been seen to paralyze a small holotrichous form with its stinging threads and, in the attempt to ingest it, the victim was pushed entirely out of reach by the long neck of its captor. In a few moments the little organism revived and swam away, leaving *Dileptus* apparently frantically seeking in all directions for that which had escaped.

In young individuals the posterior region is usually broadly rounded, the tail-like prolongation being commonly observed in maturer specimens. The nucleus is usually concealed and reagents may be necessary to render it visible.

Found in pond water and widely distributed. Reproduction is by transverse fission.

LIONOTUS Wrzesniowski.

Elongated, flexible, with a flattened ciliated ventral and a convex dorsal surface. Anterior extremity usually neck-like, posterior extremity often pointed, tail-like and curved. Oral aperture ventral. Contractile vesicles sometimes numerous.

LIONOTUS FASCIOLA Ehr.

Body elongated, ciliated on the ventral surface only, wider centrally, gradually tapering toward the narrow, flexible neck-like region, the distal extremity of which is often abruptly curved. Posterior extremity rounded, narrow. Oral aperture ventral, an indistinct, slit-like opening some distance from the anterior end. Nuclei, two spherical bodies centrally located.

Contractile vesicle single, posterior. Trichocysts along the ventral surface of the neck.

Length of body, 110 microns. (Fig. 107, Pl. XIV.)

Found in great numbers in the surface film of pond water infusions among bacteria. Reproduction may often be seen to take place by transverse fission.

LIONOTUS PLEUROSIGMA Stokes.

Body elongated, wider centrally, with a long neck-like region, slightly curved, the short caudal projection often acutely pointed and curved in the opposite direction.

Oral aperture a short distance from the anterior end. Nuclei two in number, centrally located and usually connected. Contractile vesicles numerous, arranged along the ventral and dorsal borders.

Length, 80-100 microns. (Fig. 108, Pl. XIV.)

Found associated with the last described species in infusions of pond water, among bacteria. Reproduction is by transverse fission. Conjugation may often be observed, the anterior half of the ventral borders becoming temporarily united.

LOXODES Ehrenberg.

Elongated, flattened, anterior extremity presenting a hook-like appearance. Ventral surface with fine cilia arranged in longitudinal rows, dorsal surface slightly convex with no cilia. The margin of the body with a series of strong cilia. Peristome an elongate furrow in the ventral border of the anterior extremity ending posteriorly in the mouth, which opens into a more or less distinct pharynx.

LOXODES ROSTRUM Ehr.

Body persistent in shape but very flexible, posterior extremity bluntly rounded or acutely pointed and bent to the left, as the anterior end. Oral furrow followed by an indurated tube-like pharynx. Nuclei more than one. Contractile vesicles inconspicuous.

Length, 250–400 microns. (Fig. 109, Pl. XIV.)

The body of this species is usually highly vesicular, but the number and disposition of the contractile vesicles has not yet been made out.

In all forms observed in the state but two nuclei were present, they being widely separated. Smith, of New Orleans, also reports that the species of his locality possesses but two nuclei. Careful staining has failed to reveal the racemose system of nuclei as demonstrated by Wrzesniowski. It may be that the species varies somewhat in this particular.

Found in the bottom of old infusions of pond water. Movement, a gliding motion.

TRACHELIUS Ehrenberg.

Oval or elongate, elastic. Oral aperture at the base of a short flexible neck-like extension of the anterior extremity.

TRACHELIUS OVUM Ehr.

Body oval or nearly spherical, broadly rounded posteriorly, produced anteriorly into a narrow, short, but highly flexible neck-like prolongation. Oral aperture circular, leading into a short, longitudinally striated pharynx. Nucleus central. Contractile vesicles numerous.

Length, 300 microns. (Fig. 110, Pl. XIV.)

The body of this species usually presents a highly vacuolated appearance. From the inner end of the pharynx the endoplasm spreads out into four or five broadly diverging ramifications. The nucleus is band-like or oval and sometimes two independent nuclei may be seen.

Found in fresh water but not abundant. Reproduction by transverse division.

Family, CHLAMYDODONTIDÆ.

NASSULA Ehrenberg.

Body ovate, cylindrical. Mouth lateral. Pharynx a cylindrical tube, with or without rod-like teeth, usually dilated at the exterior end. Nucleus spherical. Contractile vesicles sometimes multiple. Trichocysts often present. Body brightly colored.

NASSULA ORONATA Ehr.

Body elongated, oval or elliptical, cylindrical. Pharyngeal tube composed of a number of rod-like teeth dilated at the exterior end. Nucleus large, spherical, posteriorly located. Contractile vesicle single. Usually some shade of red or brown in color.

Length, 200 microns. (Fig. 111, Pl. XIV.)

This species has been found in a number of localities in this state, Lake Okoboji having furnished some very large specimens. Usually the pharynx is made up of twelve or more rods so united together as to form a cylindrical tube slightly dilated at the exterior end.

Usually an individual exhibits a variety of colors, which probably result from the breaking down of the algæ and other plants of low order upon which it feeds. Found in fresh water. Trichocysts are not present in this species.

NASSULA RUBENS C. & L.

Body elongate, cylindrical, equally rounded at both extremities. Pharynx made up of rod-like teeth forming a cylindrical tube, dilated at the exterior end.

Nucleus spherical, posterior. Contractile vesicle single. Trichocysts very numerous.

Length, 50–80 microns. (Fig. 112, Pl. XIV.)

This species is much smaller and less abundant than the preceding one. The presence of the trichocysts will also readily distinguish it from *Nassula oronata*.

Found in fresh water associated with the last named species. Color usually some shade of red.

CHILODON Ehrenberg.

Compressed, flexible, ventral surface flattened, with cilia arranged in longitudinal rows. Dorsal surface somewhat convex, smooth. Anterior extremity projecting to the left in a lip-like manner. Oral aperture ventral, leading into an elongated, conical pharynx provided with numerous rods. Nucleus oval, posterior to the center of the body. Contractile vesicles often numerous.

CHILODON CUCULLULUS Müll.

Body elongate-oval, rounded posteriorly. Lip-like extension prominent. Oral aperture usually anterior to the middle of the body. A groove leading from the lip-like extension to the mouth. Nucleus oval, near the inner end of the pharynx. Contractile vesicles numerous, scattered.

Length, 125–200 microns. (Fig. 113, Pl. XV.)

Chilodon cucullulus is one of the common forms of stagnant water and may also frequently be found in fresh water among algæ.

Embryos of this species differ from the adult in several particulars. The body is greatly inflated and the inner end of the pharynx is usually spirally twisted, while the nucleus is small, round, and in the posterior extremity of the body. As age advances the nucleus becomes larger, more oval in outline, and occupies a position close to the inner end of the pharynx.

The common method of reproduction is by transverse division. Conjugation may often be observed. The organism feeds upon algæ, diatoms, etc., the endoplasm frequently being packed with plants of low order.

CHILODON CAUDATUS Stokes.

Body elongate-ovate, wider anteriorly, the left-hand anterior extremity produced into a prominent lip-like extension. The posterior extremity of the flattened ventral surface somewhat acutely rounded, while the posterior extremity of the dorsal surface is drawn into a short, more or less acutely pointed, tail-like appendage, which is free from the corresponding ventral extremity. Oral aperture similar to that of *Chilodon cucullulus*.

Nucleus oval, posterior to the middle. Contractile vesicles scattered.

Length, 50–75 microns. (Figs. 114-115, Pl. XV.)

This species as found in this state presents some individual variations with respect to the posterior extremity. Frequently one surface of the posterior extremity may be broadly rounded while the other surface is acutely pointed. In other individuals both dorsal and ventral surfaces may be acutely pointed.

From a lateral point of view the posterior extremity is as represented in Fig. 115, Pl. XV, the dorsal tail-like extension being entirely free from contact with the ventral portion.

The species has been found in pond water in a few localities only in this state.

Reproduction takes place by transverse fission.

CHILODON FLUVIATILIS Stokes.

Body about twice as long as broad, rounded posteriorly, the left-hand anterior border not produced into a prominent lip-like

extension. The left-hand margin of the body nearly straight. Oral system as in *Chilodon cucullulus*. Nucleus oval, posterior to the middle of the body. Contractile vesicles numerous and scattered.

Length, 75 microns. (Fig. 116, Pl. XV.)

Not a common species in this state but has been found in Johnson county, taken from a fresh water pool among algæ and other aquatic plants.

ÆGYRIA C. & L.

Body enclosed within two valves, which are united on the dorsal border. A tail-like process extending from the posterior extremity. Oral aperture ventral, a short distance from the anterior end, followed by a tube-like pharynx.

ÆGYRIA sp. (?)

Figure 117, Plate 15, illustrates a form observed but once in this state and tentatively placed under this genus.

From a lateral point of view the body is a little longer than wide, even and broadly rounded at each extremity. Right valve traversed by three longitudinal ridges. Posterior caudal projection short, thick, and bluntly rounded, directed obliquely.

Length of valves, 175 microns.

Found in pond water in Johnson county during the fall of 1903 and not observed since. As far as I have been able to determine nearly all species of this genus previously described are reported as inhabiting salt water, but the study of this fresh water form, although somewhat brief, revealed generic characters which would place it within this genus or a very close ally.

Family, CHILIFERIDÆ.

TRICHODA Müller.

Ovate, elastic, anterior extremity narrow with border obliquely truncate, rounded posteriorly. Oral aperture terminal, provided with a minute vibratile membrane. Cilia very fine.

TRICHODA PURA Ehr.

Body elongate-oval, broadly and evenly rounded posteriorly. Anterior extremity curved, narrow, and almost pointed. Nucleus

spherical, centrally located. Contractile vesicle posterior to the nucleus. Endoplasm usually transparent.

Length of body, 40 microns. (Fig. 118, Pl. XV.)

This species has been found abundantly in long-standing infusions of pond water. It is a swift moving animalcule progressing in a straight course, usually rolling on its longitudinal axis.

Reproduction takes place by transverse division.

LEUCOPHRYS Ehrenberg.

Ovate, broadly rounded posteriorly, somewhat truncate anteriorly. Peristome short and broad, harp-shaped and confined to the anterior region. Pharynx distinct. Cilia of the left-hand border of the peristome larger than those of the general surface.

LEUCOPHRYS PATULA Ehr.

Body oval, persistent in shape, the anterior extremity obliquely truncate. Peristome broadly harp-shaped. Pharynx tubular, curved. Surface longitudinally striate. Nucleus band-like, curved, centrally placed. Contractile vesicle posterior.

Length, 200 microns. (Fig. 119, Pl. XV.)

Rarely found in this state. Habitat, fresh water among algæ.

GLAUCOMA Ehrenberg.

Somewhat oval, ventral surface flattened and ciliated, dorsal surface convex, sometimes furrowed. Oral aperture on the ventral surface, provided with a vibratile membrane. Nucleus spherical. Contractile vesicle single.

GALUCOMA SCINTILLANS Ehr.

Body oval, ventral surface ciliated. Oral aperture a little distance from the anterior extremity with the vibrating membrane extending around it, presenting a bilabial appearance. Nucleus large, spherical, situated in the central region. Contractile vesicle single, in the posterior region.

Length, 75 microns. (Fig. 120, Pl. XVI.)

When viewed laterally the oral membrane protrudes as a single tongue-like process, but from a ventral view-point the bilabial character is evident, the lips usually vibrating slowly, opening and closing the oral aperture.

Found often in great numbers associated with *Chilomonas paramæcium* in pond water infusions. Reproduction by transverse division.

GLAUCOMA sp. (?)

Body with dorsal surface convex and deeply grooved in a longitudinal direction, flattened ventrally. Oral aperture indistinct. Ventral surface clothed with cilia. Nucleus spherical, central or near the dorsal border. Contractile vesicle posterior to the middle of the body. Endoplasm usually filled with green chromatophores.

Length, 50 microns. (Fig. 121, Pl. XVI.)

During the summer of 1905 a species as described above was found abundantly in Lake Okoboji as well as other localities of the state.

The position and character of the oral aperture could not definitely be determined, although what appeared to be an oral membrane was sometimes visible on the ventral surface near the anterior extremity.

Green chromatophores usually filled the organism, being arranged in longitudinal rows between the grooves, but transparent individuals free from chlorophyl have not infrequently been observed. Nucleus seldom visible without the aid of reagents.

Reproduction by transverse fission.

Found in fresh water with aquatic plants.

This species is conditionally placed in this genus.

FRONTONIA Ehrenberg.

Elongate-oval or elliptical. Oral aperture lateral, appearing as a slit-like opening. Pharynx short with minute teeth. Surface striated longitudinally. Trichocysts usually abundant.

FRONTONIA LEUCAS Ehr.

Body elongate-oval, wider anteriorly. Oral aperture anterior to the middle of the body. Cilia fine, arranged in longitudinal rows. Contractile vesicles usually two in number. Trichocysts very numerous.

Length, 250–300 microns. (Fig. 122, Pl. XVI.)

Frontonia leucas is a common form in stagnant pond water, often

associated with *Paramæcium caudatum*, and is widely distributed over the state.

Plant tissue seems to be the chief food of this species, individuals being frequently observed almost entirely filled with algæ filaments, diatoms, etc. When this variety of food is not to be obtained, however, the organism may adopt a carnivorous habit, on one occasion a large specimen having been seen to have ingested four rotifers. The anal opening is near the posterior end at right-angles to the mouth.

Trichocysts are highly developed in this species, various chemical stimuli causing them to be extended far beyond the cilia and often cast entirely from the body.

Reproduction takes place by transverse division, a new oral aperture appearing even before constriction of the cell commences. The nucleus is concealed during life and I have not been able to demonstrate its nature or position, even by the aid of stains.

Figure 123, Plate XVI, represents a species found in Johnson county among algæ, which probably should be classified under this genus. The body is palstic but usually oval and densely packed with globular food-masses. The oral aperture has not definitely been made out although a slit-like opening, lateral and anterior in position, may sometimes momentarily be seen, but immediately closes. Contractile vesicle single. The nucleus, by the aid of reagents, is found to be greatly elongated in a medium plane of the body. I have not made a sufficient study of the organism to accurately determine its identity.

OPHRYOGLENA Ehrenberg.

Somewhat oval, flattened ventrally, convex dorsally. Oral opening anterior to the center of the body, provided with a vibratile flap-like membrane. Trichocysts often present.

OPHRYOGLENA ATRA Ehr.

Body rounded anteriorly, posterior extremity pointed. Endoplasm usually dark colored and opaque with a very dark blue pigment spot in the anterior region. Nucleus round, posteriorly situated. Contractile vesicle central.

Length, 125–150 microns. Fig. 124, Pl. XVI, a ventral view

Apparently this species is not widely distributed over the state nor is it an abundant form. It has been found in stagnant pond water associated with *Paramæcium*.

Trichocysts are well developed.

LOXOCEPHALUS Ehrenberg.

Body elongate-oval, posterior border rounded, anterior border obliquely truncate and bent to one side. Near the anterior end on one or both sides of the organism are borne one or more short setæ curved forward. From the posterior border extend one or more long setæ. Oral opening in the anterior truncated border, but indistinct.

LOXOCEPHALUS GRANULOSUS S. K.

Body elongate, nearly cylindrical, the anterior extremity truncate and slightly curved, a short curved seta borne on either side of the body near the anterior extremity. One long, straight seta projecting from the posterior border. Nucleus spherical, centrally located. Contractile vesicle posterior to the nucleus. Endoplasm granular.

Length, 40–70 microns. (Fig. 125, Pl. XVI.)

Often found in great quantities in pond water among decaying vegetable matter. The oral opening is on the oblique anterior border although quite indistinct; its presence, however, may be indicated by the fact that this region is slightly protruded at times as if the mouth were being expanded.

Conjugation of this species often occurs in infusions, the oblique anterior borders being coalesced during the process. At times the usually compact spherical nucleus may be found to be separated into from four to six small, round masses lying close together in the cytoplasm. This may represent a condition following conjugation.

Reproduction takes place by transverse division.

URONEMA Dujardin.

Ovate, or elongate. Oral aperture ventral, with an extensile membrane. Cilia of general surface vibratile. One or more long setæ extending from the posterior border.

URONEMA MARINUM Duj.

Body elongate-ovate, usually more than twice as long as broad. Cilia arranged in longitudinal rows. One long seta produced from the posterior border. Oral aperture lateral with a membrane more or less elongated but not greatly extended. Nucleus central. Contractile vesicle posterior.

Length, 30 microns. (Fig. 126, Pl. XVI.)

In general contour this species somewhat resembles *Cyclidium glaucoma*, but is larger and the cilia instead of being rigid are exceedingly vibratile, their movement being irregular and independent. The oral membrane of *Uronema* is not so highly extensile as in *Cyclidium*.

Found in fresh water, often associated with *Cyclidium* but not nearly so abundant.

COLPIDIUM Stein.

Somewhat kidney-shaped, persistent in form. Oral aperture a little distance from the anterior extremity. Pharynx with a slightly protruding, undulating membrane.

COLPIDIUM STRIATUM Stokes.

Body about twice as long as broad, the anterior extremity slightly curved toward the ventral aspect. Nucleus usually central. Contractile vesicle posterior.

Length, 60 microns. (Fig. 128, Pl. XVII.)

Colpidium striatum is a common and widely distributed form found in pond water. In general appearance it resembles *Colpidium cucullus* Schrank, (not observed in this state) which, however, possesses two nuclei.

Reproduction takes place by transverse division.

COLPODA Müll.

Resembling *Colpidium* in general outline, compressed laterally. Oral aperture ventral, in a cleft-like depression. Cilia around the mouth longer than those of the general surface.

Stokes has described several species under the generic title *Tillina* which probably should be retained within the genus *Colpoda*.

COLPODA HELIA Stokes.

Body elongated, bean-shaped, both extremities evenly rounded, the anterior one curved ventrally. Oral aperture ventral, about one-third the length of the body from the anterior end. Pharynx short, curved. Nucleus oval, central. Contractile vesicle posterior, with radiating sinuses.

Length, 100–120 microns. (Fig. 129, Pl. XVII.)

Frequently found in abundance in pond water.

COLPODA SAPROPHILA Stokes.

Body somewhat semi-circular when viewed laterally, convex dorsally, flattened ventrally.

Oral aperture near the center of the ventral surface, leading into a short, curved pharynx. Nucleus near dorsal border. Contractile vesicles one or more, posteriorly situated.

Length, 30 microns. (Fig. 130, Pl. XVII.)

When undisturbed the organism usually rests on its side so that the recurved pharynx is very conspicuous. The dorsal surface obliquely striated, the ventral border of the anterior extremity being more or less deeply notched, the notches corresponding to the striations.

Reproduction, as stated by Stokes, takes place by division or by spore formation during the encysted state.

Found in infusions of pond water, but not abundant in the state.

COLPODA FLAVICANS Stokes.

Body kidney-shaped, rounded, inflated and wider posteriorly, compressed anteriorly. Convex dorsally, flattened or concave ventrally. Oral aperture near the center of the ventral surface. Pharynx short, recurved. Nucleus central. Contractile vesicle single, posterior.

Length, 65 microns. (Fig. 131, Pl. XVII.)

The species has been found in this state in damp moss taken from trees, also in hay infusions. It is not an abundant form. The endoplasm is commonly filled with spherical food-masses.

COLPODA CAMPYLA Stokes.

Body elongate-reniform, three or four times as long as broad, the anterior extremity curved slightly toward the ventral aspect,

broader posteriorly. Oral aperture ventral, near the anterior extremity; pharynx short, curved. Nucleus spherical, central. Contractile vesicle, posterior.

Length, 100 microns. (Fig. 132, Pl. XVII.)

The body of this species is more elongated and narrower than *Colpoda helia* which it most nearly resembles. It is often found in great quantities in infusions of pond water.

Reproduction is by transverse division.

COLPODA sp.

Body short, reniform, wider posteriorly. Oral aperture ventral, anterior to the center of the body. Pharynx short, slightly curved. Nucleus central. Contractile vesicle posterior with radiating sinuses.

Length, 45 microns, (Fig. 133, Pl. XVII.)

Figure 133, Plate XVII, illustrates a small species which has been observed with *Colpoda campyla*. It shows some relation to *Colpoda helia* in the radiating sinuses of the contractile vesicle at systole, but the small size would hardly permit its classification with that species.

Reproduction takes place in this minute form by transverse division.

Family, UROCENTRIDÆ.

UROCENTRUM Nitzsch.

Somewhat pyriform, with an annular furrow not far from the posterior extremity. Two girdles of cilia are present. Oral aperture ventral in a longitudinal depression. A tail-like tuft of long cilia arising from the ventral surface, posterior to the mouth, and extending some distance beyond the posterior border of the body. Nucleus and contractile vesicle in the posterior region.

UROCENTRUM TUBRO Müll.

Body wider and broadly rounded anteriorly, rounded or truncate posteriorly. Oral aperture at the juncture of the longitudinal depression and annular furrow. The posterior tuft of cilia usually brush-like. Contractile vesicle posterior with the band-like nucleus curved around it.

Length of body, 100 microns. (Fig. 127, Pl. XVI.)

The species is a common one in pond water and often produced in great numbers in infusions. In general appearance and habits this species resembles *Calceolus cypripedium* J–Clark; the latter, however, does not possess two distinct ciliary girdles.

In movement *Urocentrum tubro* proceeds in a direct course, rolling on its longitudinal axis, or swiftly darts from side to side, often dragging after it a mass of debris which has adhered to its caudal appendage.

Reproduction is by transverse division.

Family, MICROTHORACIDÆ.

MICROTHORAX Engelmann.

Somewhat oval, flattened, the dorsal surface grooved, the ventral ciliated. Oral aperture in the posterior border on the left side, provided with an undulating membrane.

MICROTHORAX SULCATUS Eng.

Body oval, flattened ventrally, convex dorsally. The dorsal surface with three longitudinal grooves. Cilia on the ventral surface only. Nucleus spherical, central. Contractile vesicle posterior to the nucleus.

Length, 40 microns. (Fig. 134, Pl. XVII.)

A very common species in this state. Found nearly everywhere in pond water, associated with *Cinetochilum margaritaceum.*

Reproduction is by transverse division.

The species observed in this state is much smaller than that reported by Engelmann.

CINETOCHILUM Perty.

Oval, flattened, dorsal surface furrowed in a spiral manner. Mouth and contractile vesicle posterior, opposite, the former with a distinct vibratile membrane. Cilia on the ventral surface, uniform, with a number of hair-like setæ projecting obliquely from the posterior region.

CINETOCHILUM MARGARITACEUM Ehr.

Body broadly oval when viewed dorsally, flattened, with a concavity in the posterior border on the left side. Oral aperture in the posterior region on the right side of the concavity and pro-

vided with a conspicuous undulating membrane. Dorsal surface spirally striated. A few long, fine setæ, extending from the posterior border in an oblique direction, one usually longer than the others. Contractile vesicle in the posterior region opposite the oral aperture. Nucleus spherical, anterior to the contractile vesicle.

Length, 30 microns. (Fig 135, Pl. XVII.)

The oral membrane of this organism vibrates rapidly and protrudes tongue-like, apparently, however, having the power to retract so that it may sometimes be invisible from a lateral point of view.

The setæ developed from the posterior border are directed toward the left and act in the capacity of a rudder, the result being that the animal does not move forward in a straight line but continually swerves to the left, often describing circles, but always turning to the left when the dorsal surface is up.

Reproduction is by transverse fission. Found everywhere in pond water.

Family, PARAMÆCIIDÆ.

PARAMÆCIUM Müller.

Elongate-oval, entirely clothed with cilia. Mouth ventral, at the posterior end of an oblique oral groove. Nucleus and contractile vesicles conspicuous. Trichocysts usually abundant.

PARAMÆCIUM CAUDATUM Ehr.

Body elongate, anterior extremity narrow and bluntly rounded, wider posteriorly. Oral groove extending from the anterior extremity obliquely backward to or beyond the center of the body. Mouth opening into a short, curved, ciliated pharynx. A tuft of longer cilia produced at the posterior tip of the body. Macronucleus and micronucleus central in position. Contractile vesicles two, one in either extremity of the body.

Length, 230 microns. (Figs. 136–138, Pl. XVIII.)

Paramæcium caudatum is perhaps the most common ciliated protozoön known. Apparently the form differs from *Paramæcium aurelia*, as recorded by Kent, only in the possession of longer cilia at the posterior tip of the body. The "long-tailed *Paramæcium*" seems to be the characteristic variety of this country; however,

Kellicott, in western New York, reports a form without the posterior tuft of cilia, which perhaps is the European variety, *Paramæcium aurelia*.

This species, by reason of its widespread distribution and abundance, is readily accessible to the student of biology and should be examined by him because some interesting phenomena are presented by it.

The gross features of intracellular digestion may readily be followed. As food particles enter the cytoplasm they are collected into minute spherical masses by the whirling motion of the current of water and each food-mass, enclosed by a film of water, is caught up by the streaming cytoplasm and slowly transported back and forth until the digestible portions have been so reduced that they can be assimilated. The indigestible material is thrown off at the anal opening, which is ventral in position, about half way between the mouth and the posterior extremity.

The position of the macronucleus, close to the inner end of the pharynx, is of no little significance, for from this point intracellular ferments can most readily be given off to the incoming food.

The contractile vesicles are distinct and often may assume a stellate appearance, especially when mechanical pressure is applied.

Temporary conjugation of individuals of the species may frequently be observed if infusions remain for some time in the laboratory. Under these conditions large numbers of individuals may suddenly enter into a state of conjugation and after remaining united for a few days the organisms quite as suddenly separate, only to repeat the process after a period of more or less duration. Fig. 137.

During the period of union of a pair some remarkable physiological changes take place which have been carefully worked out by Maupas and Hertwig. The micronucleus of each individual divides and each portion again divides, three of these parts apparently degenerate, the other again divides, one part of which remains in a state of rest, the other passes to the companion organism and fuses with the resting portion of the macronucleus there. The macronucleus then breaks up, its fragments being scattered throughout the cell, finally degenerating, the new nuclear elements being constructed from the fused micronuclear portions. Fig. 138.

The macronucleus usually begins to break up just as the organisms are about to separate, the period of nuclear reconstruction extending over many days. After a wave of conjugation had passed, on one occasion, I observed it to require from eighteen to twenty-two days for a complete reorganization of the nuclear elements. During this time no cell division takes place, the process of conjugation, therefore, acting as a check upon rather than hastening reproduction.

Of what value then is conjugation? It is believed that as a result of activity the cell becomes physiologically exhausted, some elements vital to its existence being lost which, if not renewed, will result in death to the organism. Conjugation is a means of restoring those elements lost through natural activity of the protoplasm. Calkins, however, after recent experimental work, concludes that conjugation is a means of last resort and in a state of nature probably seldom occurs.

In the natural habitat of *Paramœcium*, where conditions are changing and new elements are ever being introduced into the water from air and soil, probably there is little need for such phenomena as conjugation. The laboratory infusion, however, does not offer these changing conditions and conjugation must frequently be resorted to.

Usually, in infusions, these periods of conjugation occur after more or less regular intervals. By the introduction into the infusion of certain elements, such as animal and vegetable extracts, salts, etc., Calkins was able to revitalize *Paramœcium*, when periods of physical depression occurred, for 742 generations.

Paramœcium caudatum is abundantly supplied with trichocysts, probably defensive weapons in this species, which are coiled just beneath the cuticular suface when not in use. Stimuli of various kinds will cause these thread-like structures to shoot out far beyond the cilia, from all points of the periphery, until the body fairly bristles with them. Weak acid solutions of various kinds will cause them to be extended; often, however, if the solution be very weak, the trichocysts will appear only at the two extremities, probably indicating that these regions are the more sensitive.

Reproduction takes place by transverse division.

Found everwhere in stagnant water and infusions.

PARAMÆCIUM BURSARIA Ehr.

Body elongated, nearly twice as long as broad, rounded posteriorly, the anterior border obliquely truncate. Oral groove broad, extending backward beyond the center of the body and terminating in the mouth. Nucleus central. Contractile vesicles two in number, one in either extremity. Endoplasm usually colored green.

Length, 120 microns. (Fig. 139, Pl. XVIII.)

Normally the endoplasm of this species is crowded with green chromatophores, the chlorophyl-bearing granules near the periphery being elongated and in their appearance are not unlike a layer of columnar epithelium.

This peripheral layer is quite permanent in position, not being shifted about by the powerful endoplasmic current which is even more noticeable than in *Paramœcium caudatum*. The green coloring matter is probably a mark of age, as apparently immature individuals have been observed almost devoid of chlorophyl.

Paramœcium bursaria is a sluggish organism, not very irritable, seldom turning on its longitudinal axis but gliding along, when in motion, with the ventral surface down.

Trichocysts are well developed.

Reproduction is by transverse fission.

This species, although not a common one in this state, may be found among algæ in fresh water. Mostly solitary.

PARAMÆCIUM TRICHIUM Stokes.

Body oval, both extremities rounded, slightly flattened ventrally. Oral groove broad anteriorly, extending obliquely backward to the center of the body, ending in an oral aperture which leads into a ciliated pharynx. Nucleus oval, centrally located. Contractile vesicles two, close together in the anterior extremity of the body. Trichocysts abundant. Endoplasm transparent.

Length, 75–100 microns. (Fig. 140, Pl. XVIII.)

Found in stagnant infusions of pond water, usually appearing in the bacteria-laden film at the surface.

Reproduction is by transverse fission.

Conjugation has often been observed to take place as in *Paramœcium caudatum*.

Family, PLEURONEMIDÆ.

LEMBADION Perty.

Oval when viewed dorsally, flattened ventrally. Peristome broad and long, occupying the greater portion of the ventral surface, with a conspicuous undulating membrane on the left border. Oral aperture at the posterior end of the peristome provided with a delicate membrane. A number of rigid cilia, much longer than those of the general surface, projecting from the posterior border of the body.

LEMBADION BULLINUM Perty.

Having the characters of the genus. Nucleus elongated, curved, in the posterior region on the left side; contractile vesicle also posterior, opposite the nucleus.

Length, 50–100 microns. (Fig. 141, Pl. XIX.)

This species, on a few occasions, has been found abundantly in this state in pond water, among aquatic plants.

Normally the movement of the organism is in a direct course, but when stimulated it swims rapidly backward, rotating on its longitudinal axis. Usually from four to six posterior setæ are present.

Reproduction is by transverse division.

CYCLIDIUM Ehrenberg.

Oval, slightly compressed dorso-ventrally, persistent in form. Oral aperture ventral, with an extensile membrane. Cilia long, rigid; one or more long, hair-like setæ projecting from the posterior border.

CYCLIDIUM GLAUCOMA Ehr.

Body ovate, slightly concave on the ventral surface. Oral aperture anterior to the middle of the body, with a hood-like membrane. Cilia very long and rigid, arranged in longitudinal rows. A single posterior seta much longer than the cilia of the general surface. Nucleus central. Contractile vesicle posterior.

Length, 20 microns. (Fig. 142, Pl. XIX.)

Cyclidium glaucoma is abundant in this state in both stagnant and fresh water. Often great swarms of these animal organisms

are seen in a single drop of water, darting about and suddenly coming to rest like so many flies.

Reproduction takes place rapidly by transverse division.

CTEDOCTEMA Stokes.

Elongate-oval, cilia of the general surface long and rigid, with a longer seta projecting from the posterior border. Oral groove long and narrow with a series of long, curved setæ on the right-hand border. Oral aperture at the posterior end of the groove. Nucleus single, in the anterior region. Contractile vesicle single in the posterior region. Trichocysts abundant.

CTEDOCTEMA ACANTHOCRYPTA Stokes.

Body ovate, wider posteriorly. Cilia long, rigid, with a longer hair-like seta, curved at the distal end, projecting from the posterior border. Oral aperture at the posterior end of a shallow ventral groove which extends nearly the entire length of the body. From the right-hand margin of the groove extends a series of long rigid cilia gradually diminishing in length as they approach the oral aperture. From the left-hand margin of the groove extends a series of fine vibratile cilia also decreasing in length posteriorly. Nucleus oval in the anterior extremity of the body. Contractile vesicle posterior. Trichocysts very numerous.

Length of body, 25 microns. (Fig. 143, Pl. XIX.)

This species has been found abundantly in Johnson county among fresh water algæ. In general contour the body somewhat resembles *Cyclidium*.

On the lateral border near the posterior extremity of the body there may at times be seen a bubble-like outpushing of the protoplasm, but the ectoplasm apparently does not burst as, in a short time, the protruded portion is withdrawn, the phenomenon soon to be repeated.

The distal ends of the rigid cilia bordering the ventral groove adhere, giving the appearance under low magnification of a long, recurved seta arising from the posterior end of the groove.

Chemical stimuli may cause the trichocysts to be extended. They are stout, about 15 microns in length, and appear to be thickened at the distal end. This thickening, according to Stokes who discovered and described the species, is due to minute

linear processes, usually four, radiating from the tip of the trichocyst.

Reproduction takes place by transverse division.

Family, CYRTOLOPHOSIDÆ.

CYRTOLOPHOSIS Stokes.

Ovate, a tuft of hair-like setæ, curved distally, extending from the anterior extremity. The organism secreting, when at rest, an enveloping zone of mucilaginous substance. Oral aperture at the posterior end of a short groove on the ventral surface. A series of large cilia on the margin of the oral groove.

CYRTOLOPHOSIS MUCICOLA Stokes.

Body elongate-ovate, wider posteriorly, the anterior border obliquely truncate. Cilia of the general surface somewhat rigid, those on the margin of the oral groove longer anteriorly and diminishing in length posteriorly. Nucleus central. Contractile vesicle posterior. Mucilaginous envelope apparent when at rest.

Length, 25 microns. (Fig. 144, Pl. XIX.)

This strange form has been frequently observed in fresh water infusions among algæ and other aquatic plants. As soon as the organism comes to rest a transparent, sticky substance seems to be exuded from the body, its presence and boundaries indicated by granules of various kinds, probably partially excretory, bacteria and foreign particles of diverse nature which adhere to and become imbedded in the secretion. When disturbed the organism glides out of this covering and when it becomes quiet again another excreted zone is formed. Stokes, who has created a new family for this species, reports that the "zoöcytia" of several individuals may sometimes be united, thereby building up a temporary colony.

The prominent setæ extending from the anterior extremity are very efficient, even when the organism is at rest a powerful current of water bearing food particles being forced down the oral groove by their vibrations.

Reproduction is by transverse division.

Order, HETEROTRICHA.
Family, PLAGIOTOMIDÆ.

BLEPHARISMA Perty.

Elongate, flattened, pointed and curved to the left anteriorly, rounded or truncate posteriorly. Oral groove, a deep furrow on the left-hand border usually reaching from the anterior end to the middle of the body where it leads into a short pharynx. A series of large cilia on the left-hand border of the peristome, on the right-hand border, an undulating membrane. Color, some shade of pink or red.

BLEPHARISMA LATERITIA Ehr.

Body somewhat lanceolate, often truncate posteriorly. Peristome reaching to the middle of the body. Undulating membrane, bristle-like in appearance, sometimes not very conspicuous. Nucleus oval, in the anterior half of the body. Contractile vesicles posterior. Color, peach-bloom.

Length, 150 microns. (Fig. 145, Pl. XIX.)

Found in Lake Okoboji and a few other places of the state. Habitat, fresh water among aquatic plants. Although the organism normally possesses coloring matter, transparent individuals may often be observed. The highly-colored body also immediately becomes transparent on the application of fumes of osmic acid.

Reproduction is by longitudinal division.

METOPUS C. & L.

Usually elongate-oval, but changeable in form, anterior extremity usually twisted obliquely over the ventral surface. Oral groove narrow, furrow-like, extending obliquely from left to right nearly to the middle of the body. Oral aperture at the posterior end of the furrow, opening into a short pharynx.

METOPUS SIGMOIDES Müll.

Body usually elongate, the anterior extremity twisted over the ventral surface. Cilia covering the entire body but somewhat longer at the posterior extremity. Nucleus oval, situated centrally. Contractile vesicle posterior.

Length, 100–200 microns. (Fig. 146, Pl. XIX.)

This species is found in pond water at the bottom of old infusions of decaying vegetable matter. A variety of forms may

be assumed by the same individual; sometimes the posterior region is flattened and at times the anterior extremity lacks the obliquely twisted appearance. A form, which probably is a phase of this species, has been observed in Johnson county, with a greatly inflated posterior region and an acute anterior twisted extremity.

In the anterior extremity of the normal specimen the endoplasm usually encloses a mass of dark pigment-like granules. The motion of the organism is accompanied by a slow revolution on its longitudinal axis.

METOPIDES Quennerstedt.

Ovate or pear-shaped, usually broader anteriorly. The anterior region folded obliquely across the ventral surface. Oral furrow produced by the folded portion. Oral aperture at the posterior tip of the furrow. Cilia of oral groove large, a tuft of long setæ produced from the posterior border.

METOPIDES ACUMINATA Stokes.

Body pear-shaped, broadly rounded anteriorly, tapering toward a posterior, tail-like prolongation from which extend a number of long, slender setæ. Nucleus spherical, centrally located. Contractile vesicle in the posterior region.

Length, 75 microns. (Fig. 147, Pl. XX.)

This species differs from *Metopus sigmoides* principally in the contour of the body and the presence of the posterior tuft of long setæ. Endoplasm is usually transparent and the nucleus visible without the aid of reagents. Found in stagnant water but not abundant. In motion, rapidly rotating on the longitudinal axis.

SPIROSTOMUM Ehrenberg.

Greatly elongated but highly contractile, cylindrical, anterior border rounded, posterior border often truncate. Oral furrow extending from the anterior extremity backward to the middle of the body, the left-hand border strongly ciliate. Pharynx short. Body contracting spirally.

SPIROSTOMUM AMBIGUUM Ehr.

Body elongated, from ten to fifteen times as long as broad. Oral aperture at the posterior end of the longitudinal oral furrow. Nucleus moniliform, greatly elongated. Contractile vesicle

occupying the posterior extremity and extending forward, canal-like, nearly to the anterior end.

Length of the extended body, 500–2800 microns. (Fig. 148, Pl. XX.)

Spirostomum ambiguum, which is one of the most elongated free-swimming ciliates known, is a very common species in pond water among aquatic plants. The organism is extremely sensitive, quickly contracting into a short, spiral body on the slightest disturbance. Fig. 149.

Reproduction is by transverse division.

SPIROSTOMUM TERES C. & L.

Differing from *Spirostomum ambiguum* in the following characters: Body shorter and narrower. Oral furrow not so long in proportion to the length of the body. Nucleus oval, centrally located.

Length of extended body, 300–500 microns. (Fig. 150, Pl. XX.)

Very commonly associated with the last named species.

Family, BURSARIDÆ.

CONDYLOSTOMA Dujardin.

Ovate or elongate, cylindrical. Peristome short in proportion to the length of the body, provided with an undulating membrane and strong cilia. Nucleus moniliform, elongated. Contractile vesicles often numerous.

CONDYLOSTOMA sp.

Body elongate, cylindrical, and somewhat elastic, rounded posteriorly, posterior extremity abruptly curved toward the ventral aspect and terminating in an acutely pointed tip. Peristome, a furrow-like depression extending about one-sixth the length of the body, bearing on the right side an undulating membrane, on the left margin a series of strong cilia. Nucleus moniliform, elongated, ventral in position. Contractile vesicles more than one.

Length, 150–200 microns. (Fig. 151, Pl. XX.)

Figure 151 was taken from a fixed specimen slightly contracted, the normal individual being somewhat more elongated than is

represented by the drawing. This species is apparently distinct from *Condylostoma patens* Müll. in the general contour of the body which, in the forms observed here, has been as described above. In no case was the posterior region the widest of the two extremities and in none of the Iowa forms was a canal-like contractile vesicle present, but usually one prominent vesicle and two or three smaller ones.

Found in Jefferson county in an infusion of pond water.

UNIDENTIFIED SPECIES.

Figure 152, Plate XX, represents a species the identity of which is, as yet, undetermined. It has been observed in this state only in Johnson county, in fresh water among algæ.

Body elongate-oval, broadly rounded anteriorly, more acutely rounded posteriorly. Peristome a deep broad depression extending backward nearly to the middle of the body, bearing on the left-hand margin a row of long cilia and on the right-hand a conspicuous undulating membrane. Pharynx indistinct. Body entirely ciliated. Nucleus large, irregular in shape, central. Contractile vesicle in the posterior region, lateral.

Length, 250 microns.

None of the individuals observed at any time were brightly colored, but very transparent. The character of the oral region and nucleus would ally the form to *Blepharisma*, but the characteristic shape of the body precludes this, nor does it seem to belong to the genus *Condylostoma* on account of the nature of the nucleus.

Family, STENTORIDÆ.

STENTOR Oken.

Free-swimming or attached. When fully extended, elongate, trumpet-shaped, anterior end truncate, tapering toward a narrow foot which may be attached temporarily to some support or to the bottom of a soft, mucilaginous lorica. Anterior border bearing a spiral row of large cilia, the left-hand end of the spiral being the lower, leading into the mouth and short pharynx. Surface striate longitudinally, finely ciliate, sometimes bearing, in addition, long slender setæ. Nucleus moniliform, band-like or oval. Contractile vesicle in the anterior extremity.

STENTOR CÆRULEUS Ehr.

Body of a very large size, more or less densely blue in color. Nucleus conspicuous, moniliform.

Length of the extended body, 250–300 microns. (Fig. 153, Pl. XXI.)

In mass this species is one of the largest of fresh water Protozoa, being readily visible to the unaided eye, and often gathered in great social clusters.

Reproduction commonly takes place by oblique division of the body, the first indications of fission being the appearance on the ventral surface of an elongated vibratile membrane which soon breaks transversely into a fringe of long cilia. The anterior extremity of this fringe curls around, meeting the lower end and forming the peristomal cilia for the new individual. Separation of the body then occurs, in an oblique direction. This method is the usual one for all members of the genus and is illustrated by Figs. 154–156, Pl. XXI, which probably is another species.

Reproduction in *Stentor cæruleus* may also take place by the production of internal embryos. Probably originating from the bead-like elements of the nucleus, the embryos assume the essential characters of the adult within the endoplasm of the parent, and finally break out through the cuticular surface. This method of reproduction has been reported to occur in other species of the genus but has come under my observation only in *Stentor cæruleus*. The nucleus is usually visible without the aid of reagents, distinctly moniliform, and sometimes may be branched. The contractile vesicle is spherical, often with a conspicuous canal leading posteriorly.

A common form, widely distributed, found in old infusions of fresh water after fermentation has taken place.

STENTOR RŒSELII (?) Ehr.

Body transparent, greatly elongated when fully extended, sometimes secreting a mucilaginous sheath. Long, slender setæ often extended from the periphery. A tuft of short, fine setæ developed from the posterior extremity. Nucleus elongated, band-like.

Length, when extended, 500–1000 microns. (Figs. 154-156, Pl. XXI.)

A form not uncommon to infusions of decaying vegetation is referred conditionally to the above species. In most respects the organism corresponds to the description of *Stentor rœselii* although a mucilaginous sheath has never definitely been made out for any of the individuals observed in this state. The body is transparent throughout the life-cycle, the nucleus is never moniliform, and long slender setæ, which are retractile at will, often extend far beyond the cilia of the general surface.

The transparency of the organism together with the band-like nucleus and well developed cuticular setæ are specific characters which, I believe, exclude the form from the species *Stentor polymorphus* or *Stentor cœuruleus*.

Reproduction is as represented by Figs. 154-156, Pl. XXI, and previously described under *Stentor cæruleus*. Multiplication of this species by means of internally produced embryos has been reported by Claparede and Lachmann.

STENTOR POLYMORPHUS Müll.

Characters correspond to those of *Stentor cæruleus* except that the peripheral zone of the body is usually densely packed with green chromatophores.

Length, when extended, 500–1000 microns.

Because of its general resemblance to *Stentor cæruleus* no figure has been drawn of the species. The large size, green color, together with the moniliform nature of the nucleus, will distinguish the species from other members of the genus.

Stentor polymorphus may frequently be found in fresh water among green algæ and in the late fall often collects in great masses on the under side of rocks, in pools or small streams, where a quiescent state is passed during the winter months.

Reproduction commonly takes place by oblique fission.

Family, GYROCORIDÆ.

GYROCORIS Stein.

Anterior region helmet-shaped, rounded anteriorly, with a free posterior region. Posterior region produced into a long, curved, tail-like process. Oral aperture ventral in a ciliated groove. Cilia extending from the mouth in a spiral across the anterior border and around the free margin of the posterior region.

GYROCORIS OXYURA Stein.

Possessing the characters of the genus. Tail-like process with a broad base and even exceeding the body in length. Nucleus moniliform, short, usually composed of three bead-like masses united, and transversely placed, in the posterior region. Contractile vesicle also posterior.

Length, including caudal process, 110–150 microns. (Fig. 157, Pl. XXI.)

A rare species in this state, but found in Johnson county in pond water among decaying plants. The organism moves swiftly, rotating on its longitudinal axis.

Conjugation has often been observed to take place, the ventral surfaces of the conjugants being united.

Family, HALTERIIDÆ.

HALTERIA Dujardin.

Spheroidal, with a spiral wreath of large cilia about the anterior border. Oral aperture eccentric, on the anterior margin, the equatorial region bearing a circle of long, fine, springing setæ.

HALTERIA GRANDINELLA Müll.

Body usually somewhat spherical, truncate anteriorly, broadly or acutely rounded posteriorly. Body without cilia except the anterior wreath and the equatorial circle of springing-hairs. Nucleus oval or round, centrally located. Contractile vesicle near the nucleus. Endoplasm transparent.

Length of body, 25 microns. (Fig. 158, Pl. XXI.)

Halteria grandinella moves by a rotary motion on its longitudinal axis accompanied by frequent sudden leaps, which are said to be due to the reflex of the fine springing setæ.

The species is common to pond water and is widely distributed. It has also been found in great quantities in spring water among algæ.

Order, HYPOTRICHA.
Family, OXYTRICHIDÆ.

UROSTYLA, Ehrenberg.

Elongate-oval, very flexible. Frontal styles three or more, anal styles from five to twelve, slender and in an oblique row.

Ventral surface covered with fine cilia arranged in longitudinal rows. Peristome triangular. Nuclei usually more than one. Contractile vesicle single.

UROSTYLA GRANDIS Ehr.

Body rounded at each extremity, narrower anteriorly. Peristome triangular, reaching backward nearly one-third the length of the body, the posterior angle curved. Frontal styles numerous, scattered. Ten or twelve slender anal styles; ventral rows of cilia numerous. Marginal series of setæ complete. Nuclei usually two. Contractile vesicle on the left side anterior to the middle.

Length, 250–400 microns. (Fig. 159, Pl. XXII.)

Found in fresh water. The forms observed in this state possessed two nuclei each with a distinct micronucleus attached.

The endoplasm often presents a yellowish appearance due, probably, to the ingested diatoms and other unicellular plants upon which the organism ravenously feeds.

STICHOTRICHA Perty.

Wider posteriorly, anterior region slender, neck-like and very flexible. Peristome, a furrow leading backward to the middle of the body and ending in the mouth. Frontal styles sometimes wanting, one or more oblique rows of large ventral setæ, no anal styles. Marginal setæ forming a complete border.

Anterior half of the body often with very long, slender, hair-like setæ. Animal sometimes inhabiting a lorica.

STICHOTRICHA ACULEATA Wrzes.

Body with posterior extremity bluntly pointed. Two prominent styles extending from the anterior border, ventral setæ in two oblique rows. The anterior body-half bordered by two opposite rows of very slender hair-like setæ.

Oral furrow bordered with long, fine cilia. Nuclei two, centrally located. Contractile vesicle posterior to the mouth.

Length, 120 microns. (Fig. 171, Pl. XXIV.)

This species has been obtained from fresh water in Cedar county, but is not a common form in this state. It has not been found inhabiting a lorica or sheath of any kind, but has always been observed as a free-swimming organism.

UROLEPTUS Ehrenberg.

Greatly elongated in comparison to the width, and highly flexible; rounded anteriorly, posterior extremity extremely narrow, tail-like. Three or four frontal styles, ventral styles in two longitudinal rows; no anal styles. Marginal series of setæ set well in on the ventral surface.

UROLEPTUS RATTULUS Stein.

Body sometimes exceeding in length eight times the width, tapering from near the middle toward the acutely pointed posterior extremity, this posterior third of the body being very narrow, flexible and tail-like. Peristome short, about one-sixth the length of the body. Nuclei two in number, with the contractile vesicle between them.

Length, 500 microns. (Fig 164, Pl. XXIII.)

This species has been found in long-standing infusions of decaying vegetation, but is not a common form in this state.

Movement is by short, interrupted motions, which are characteristic also of other members of this family.

Reproduction is by transverse division.

UROLEPTUS AGILIS (?) Eng.

Body four or five times as long as broad, wider centrally, tapering posteriorly toward a narrow, bluntly rounded extremity which may be slightly turned to the right. Frontal styles four, several scattered ventral styles sometimes produced in addition to the double row. Marginal setæ forming a complete series, projecting beyond tbe border, and somewhat longer in the posterior region.

Peristome reaching nearly one-fourth the length of the body. Nuclei two in number, in the central region. Contractile vesicle on the left side a little in front of the middle.

Length, 300 microns. (Fig. 165, Pl. XXIII.)

The plate figure illustrates a form not infrequently found in fresh water in several localities of this state and which, as far as I have been able to determine, corresponds most closely to this species.

Reproduction and manner of movement as in *Uroleptus rattulus*.

PLEUROTRICHA Stein.

Elongate-oval, with from five to eight frontal styles, ventral styles usually arranged in two rows with a few scattered additional ones, anal styles five or six, two of them near the posterior border. Marginal setæ forming a complete border. Peristome extending about one-third the length of the body.

PLEUROTRICHA LANCEOLATA Ehr.

Body nearly three times as long as broad, wider centrally, tapering toward each extremity but narrowest and somewhat pointed posteriorly. Two right-hand styles arising near the posterior border and projecting beyond it for nearly their entire length. Nuclei two in number, one placed anterior to the apex of the peristome. Contractile vesicle on the left side posterior to the peristome.

Length, 250 microns. (Fig. 160, Pl. XXII.)

Somewhat resembling *Stylonychia* but possessing no caudal setæ and having the anal styles arranged in two groups.

Found in fresh water among algæ but apparently not abundant in this state.

GASTROSTYLA Engelmann.

Elongate-oval, with five or six frontal styles and usually as many anal. Ventral styles in an oblique row. The series of marginal setæ complete. Peristome triangular, curved and provided with an undulating membrane.

GASTROSTYLA STEINII Eng.

Body evenly rounded at each extremity. The three frontal styles near the anterior border very large. Three or four scattered ventral styles besides the oblique row. Five anal styles in an oblique row not projecting beyond the posterior border. Peristome extending about one-third the length of the body. Nuclei four in number in a longitudinal row. Contractile vesicle on the left side near the middle of the body.

Length, 250 microns. (Fig. 161, Pl. XXII.)

Found in fresh water.

OXYTRICHA Ehrenberg.

Elongate-oval, or elliptical, very elastic. Three or more frontal styles, a few scattering ventral setae and five anal styles. Peris-

tome about one-third the length of the body. Nuclei two. Contractile vesicle single.

OXYTRICHA PELLIONELLA Müll.

Body elongate-elliptical, wider centrally and tapering toward each extremity. The marginal setæ are set well in on the ventral surface. Three prominent frontal styles, and five anal styles arising near the posterior border and extending nearly their full length beyond it, sometimes bent at their distal ends.

Nuclei two, both posterior to the mouth. Contractile vesicle on the left side near the posterior tip of the peristome.

Length, 80-100 microns. (Fig. 167, Pl. XXIII.)

Oxytricha pellionella is one of the common species of the family found in both stagnant infusions and fresh water. The flexibility of the body is remarkable as it twists in and out among aquatic plants. In the open its movement is a short jerky motion peculiar to this and other species of the family.

Reproduction by transverse division. Distribution general.

OXYTRICHA PLATYSTOMA Ehr.

Body elongate-oval, posterior extremity slightly narrower than the anterior. Usually five frontal, three to five scattered ventral setæ and five anal styles, none of which project beyond the posterior border. Marginal setæ forming a complete series. Peristome area deep, extending about one-third the length of the body, the anterior extremity of the right-hand margin conspicuously curved to the left in a spiral manner. Nuclei two in number. Contractile vesicle on the left side, anterior to the middle of the body.

Length, 150 microns. (Fig. 168, Pl. XXIII.)

This species may readily be distinguished by the spiral nature of the right-hand margin of the peristome area, which can be distinctly seen even from a dorsal view point. The species is not common in this state. Habitat, fresh water, with other species of the genus, which it resembles in movement, manner of reproduction, etc.

HISTRIO Sterki.

Somewhat elliptical in shape, inflexible. Frontal styles from five to eight, ventral five, anal five. Marginal setæ forming a complete fringe. Peristome extending to, or nearly to, the middle

of the body. Nuclei two in number, contractile vesicle single, on the left-hand side, near the middle.

HISTRIO STEINII Müll.

Body elliptical, more than two times as long as broad, wider centrally, evenly rounded at the ends. Three prominent frontal styles with three or four additional smaller ones. Ventral styles scattered. None of the five anal styles projecting beyond the posterior border. Nuclei two, oval in form, one anterior to the mouth.

Length, 160 microns. (Fig. 166, Pl. XXIII.)

Found frequently in fresh water, and also in infusions of pond water, in many localities of the state. Reproduction is by transverse division.

STYLONYCHIA Ehrenberg.

Elongate-oval in shape, inflexible. Eight frontal, five ventral and five anal styles. Three long, hair-like setæ, usually developed from the posterior border. Peristome triangular, with a broad base and sometimes with an undulating membrane.

STYLONYCHIA MYTILUS Ehr.

Body elongate-oval, wider anteriorly, tapering toward a narrow posterior extremity. Two right-hand anal styles, large and stout, extending beyond the posterior margin. The hair-like caudal setæ very long and flexible. Peristome wide, extending nearly to the middle of the body, the inner border with an undulating membrane. Nuclei two, one anterior to the mouth. Contractile vesicle single, near the left lateral border, posterior to the peristome.

Length, 200-400 microns. (Fig. 169, Pl. XXIII.)

Stylonychia mytilus is one of the largest species of the family occurring in the waters of this state. The posterior extremity of the body is often variable in shape and character, sometimes being pointed and curved, sometimes truncated, but nearly always sharply contrasted, by its transparency, with the remaining more granular portion of the body.

Frequently the anal styles and caudal setæ present a branched appearance. Reproduction is by transverse division. Distribution is general. Found in infusions of pond water.

STYLONYCHIA sp.

Figure 170, Plate XXIII, represents a species of this genus found commonly among algæ in the fresh waters of Johnson county. So far as I have been able to determine the form does not correspond with any described species. Conn, in a recent report entitled "The Protozoa of the Fresh Waters of Connecticut," Fig. 267, Pl. 29, illustrates a species of *Stylonychia* which apparently corresponds very closely to the Iowa form as described below and may be identical with it.

Body elongate-oval, wider anteriorly, rounded posteriorly. Right-hand border convex, left-hand more or less concave, giving the body a bent appearance. Two of the anal styles extending beyond the posterior border. Caudal setæ exceedingly long and flexible.

Endoplasm often partially or completely filled with green chromatophores.

Length, 200–300 microns.

STYLONYCHIA PUSTULATA Ehr.

Body oval, about twice as long as broad, rounded at each extremity. Caudal setæ short. Nuclei two. Contractile vesicle single.

Length, 150–170 microns. (Fig. 162, Pl. XXII.)

This species is usually common in infusions of stagnant water, often developing in great numbers. Reproduction takes place rapidly by transverse fission. Movement, as in other members of the family, is a quick, jerky motion.

Distribution over the state is general.

STYLONYCHIA NOTOPHORA Stokes.

Body elongate-elliptical, rounded posteriorly, the front margin obliquely truncate on the left side, rounded or slightly concave on the right side. Five scattered ventral styles; three anal styles project beyond the posterior border. Caudal setæ long and widely separated, having their origin on the dorsal surface near the posterior margin. Peristome extending nearly to the middle of the body, the left-hand border with an undulating membrane. Nuclei two in number. Contractile vesicle single, on the left side, on a level with the posterior angle of the peristome.

Length, 120-160 microns. (Fig. 163, Pl. XXII.)

This is the rarest of the four species of the genus thus far observed in this state. It has been found in pond water, associated with other members of the family, in Cedar county. In manner of reproduction, movement, etc., it resembles other species of the genus.

Family, EUPLOTIDÆ.

EUPLOTES Ehrenberg.

Persistent in shape, inflexible, oval, ventral surface flattened, dorsal surface convex and longitudinally furrowed. From six to eight styles about the front border, a few scattered ventral ones, five anal styles and usually four large setæ on the posterior margin. Peristome extending backward to or beyond the middle of the body. Nucleus band-like, curved. Contractile vesicle in the posterior region and lateral.

EUPLOTES CHARON Müll.

Body a little longer than broad, the dorsal surface conspicuously ribbed. Seven frontal styles and three ventral. Peristome extending beyond the middle of the body.

Length, 80 microns. (Fig. 172, Pl. XXIV.)

The plate figure represents a dorsal view showing the ribbed surface. This form can usually be distinguished from the more common species, *Euplotes patella*, by the shorter oval body and the greater number of frontal styles.

Found in fresh water.

EUPLOTES PATELLA Ehr.

Body elongate-oval, evenly rounded posteriorly, truncate or rounded anteriorly. Usually six frontal and two or three scattered ventral styles. Of the four setæ on the posterior margin, two are usually somewhat lateral in position.

Peristome broad, extending nearly to the middle of the body. Nucleus band-like, curved, following the contour of the body. Contractile vesicle posterior and lateral.

Length, 150 microns. (Fig. 173, Pl. XXIV.)

This is the most common species of the genus to be found in this state and one in which individual variation is shown to a remarkable degree. Frequently the setæ of the posterior border,

the anal styles and some of the frontal styles, are observed to be frayed or broken up into brush-like fascicles. The dorsal surface may or may not be longitudinally ribbed, this feature, apparently, not being so constant as in *Euplotes charon*.

Reproduction takes place rapidly by transverse division. Conjugation also frequently occurs in infusions.

EUPLOTES CARINATA Stokes.

Body somewhat oval, evenly rounded at the extremities and the right lateral border. Left-hand border obliquely truncate in two directions, forming a projecting angle. Seven frontal styles, two or three ventral ones, five anal styles and four caudal setæ, two close together near the posterior border and two more lateral in position toward the left. Peristome extending nearly to the middle of the body. Dorsal surface usually furrowed. Nucleus band-like, curved. Contractile vesicle posterior to the middle and somewhat lateral.

Length, 60 microns. (Fig. 174, Pl. XXIV.)

A rare form in the waters of this state. Found in pond water among decaying vegetation, from Washington and Monroe counties.

ASPIDISCA Ehrenberg.

Oval or rounded, persistent in form, convex and usually furrowed dorsally, flattened ventrally. Frontal, ventral and anal styles present, from five to twelve of the latter. No caudal setæ. Peristome in the posterior region, in the left-lateral border. Nucleus band-like, curved. Contractile vesicle single.

ASPIDISCA COSTATA Duj.

Body somewhat rounded from a dorsal or ventral point of view. Convex dorsal surface with five or six longitudinal furrows. When veiwed dorsally the left postero-lateral region produced into a triangular, lip-like extension, indicating the oral region. Usually three frontal styles, four or five scattered ventral and five anal styles. Nucleus band-like, curved. Contractile vesicle usually in the posterior region, slightly lateral.

Length, 35 microns. (Figs. 175–176, Pl. XXIV.)

Aspidisca costata is found almost everywhere in infusions of pond water. The oral aperture is covered by the projecting lip-

like extension. This species presents some peculiarities in its habit of movement, never seeming at ease unless it is clambering around and around on a minute particle of plant tissue. When it loses its hold upon its support it rolls and tumbles at random through the water until it comes in contact with some other support.

Reproduction is by transverse fission

Order, PERITRICHA.
Family, VORTICELLIDÆ.

GERDA C. & L.

Elongate, cylindrical, highly contractile, not attached to but resting upon some support. Oral aperture on the anterior border, eccentric, opening into a distinct pharynx. A series of strong adoral cilia in a spiral fringe about the central, elevated, ciliary disc, one extremity of the series descending into the oral opening.

GERDA GLANS C. & L.

Body about four times as long as broad when fully extended, surface transversely striated. Pharynx greatly developed. Nucleus band-like, longitudinally placed. Contractile vesicle posterior, with canals directed anteriorly.

Length when extended, 150 microns. (Fig. 177, Pl. XXV.)

Gerda glans has been found in one locality only in this state, in Johnson county, among algæ. The individuals are usually isolated and rest upon the plant tissue for support, but are not attached to it. Reproduction takes place by longitudinal division.

SCYPHIDIA Dujardin.

Elongate, cylindrical, contractile. Posterior extremity narrow, with a suctorial border, by means of which it is attached to some support. Surface smooth or furrowed. Oral system similar to that of *Gerda*.

SCYPHIDIA INCLINANS D'Udk.

Body wider centrally, highly contractile. Ciliary disc elevated obliquely, pharynx conspicuous. Surface smooth.

On contraction the body is bent to one side and slightly shortened.

Length when extended, 85 microns. (Figs. 178–179, Pl. XXV.

This organism is solitary in its habits and has rarely been observed in this state. Habitat, fresh water among algæ. When contracted the peristome is tightly closed and a small conical process appears in the central region of the anterior margin; at the same time the body is thrown on its side, the concave surface being folded.

SCYPHIDIA sp.

Body elongate, cylindrical, contractile, wider anteriorly, gradually tapering toward the narrow posterior extremity. Ciliary disc slightly elevated. Posterior half of the body furrowed transversely, anterior half smooth. Contractile vesicle anterior. Body pyriform when contracted.

Length of extended body, 50–75 microns. (Figs. 180–181, Pl. XXV.)

This species above described and referred to this genus has been found in Poweshiek county. Habitat, fresh water. So far as can be determined, I find no described species corresponding to the funnel-shaped contour and posterior transversely striated region of this organism.

VORTICELLA Linnæus.

Body more or less bell-shaped, attached by an elongate, contractile stalk. Peristome usually prominent. A series of strong cilia encircle the central elevated region or ciliary disc, the right extremity of the series descending into the oral opening, which is eccentric in position between the peristome and the ciliary disc. Pharynx usually conspicuous. Nucleus band-like, curved. Surface smooth or transversely striate. Contractile vesicle in the anterior region.

All members of this genus are similar in general features, making it somewhat difficult to recognize separate species. However, variations of the form of the bell, and the character of its surface, positions of the ciliary disc, size and length of the stalk, are characters which are of assistance in distinguishing one species from another. Although many forms are social to a remarkable degree, colonies are never built up, longitudinal fission resulting in the complete liberation of one-half of the dividing zoöid. The separated individual having previously developed a posterior

wreath of cilia, swims away and settles down, developing a stalk of its own. Thus the cycle of life repeats itself.

When conditions are unfavorable normal individuals may develop a posterior circle of cilia, break from their pedicels and swim away to form another stalk under more favorable surroundings.

Conjugation in this group consists of a permanent union of two individuals, the larger, attached macrogamete and the smaller free-swimming microgamete, which attaches itself to the body of the stalked form. On one occasion, as observed by the writer, the complete absorption of the microgamete required eight hours.

VORTICELLA CAMPANULA Ehr.

Body broadly campanulate, greatly dilated anteriorly, surface smooth. Stalk thick, usually five or six times the length of the body. Endoplasm dark granular, often opaque.

Length of body, 150 microns. (Fig. 182, Pl. XXV.)

A common species in pond water, also found in great social groups on the under side of stones, leaves, etc., in small running streams. The collared flagellate, *Monosiga steinii*, is often attached to the pedicle of this species.

VORTICELLA NUTANS Müll.

Body campanulate, dilated anteriorly, surface smooth. Stalk slender, three or four times as long as the body. Endoplasm usually transparent. During extension the body is recurved toward the base of the stalk.

Length of body, 80 microns. (Fig. 183, Pl. XXV.)

Found in pond water in social groups.

VORTICELLA ALBA From.

Body oval, wider centrally, anterior border not greatly dilated, surface smooth. Stalk short, about three times the length of the body. Endoplasm transparent.

Length of body, 55 microns. (Fig. 184, Pl. XXV.)

Found in social groups in pond water.

VORTICELLA LONGIFILUM S. K.

Body elongate, anterior border not widely dilated. Surface smooth. Stalk slender, from twelve to fifteen times the length of the body.

Length of body, 60 microns. (Fig. 191, Pl. XXVI.)

Found in pond water, solitary in its habits.

VORTICELLA TELESCOPA S. K.

Body conical, elongate, tapering posteriorly. Two annular grooves in the posterior region, behind each of which the body abruptly narrows. On contraction the narrow regions are telescoped into the wider anterior regions. Surface smooth.

Stalk not much longer than the body.

Length of body, 40–50 microns. (Fig. 185, Pl. XXV.)

Found in Washington county, in pond water. Solitary in its habits.

VORTICELLA CITRINA Ehr.

Body campanulate, anterior border greatly dilated, surface smooth. Endoplasm pale yellow in color. Stalk slender, three or four times the length of the body.

Length of body, 60 microns. (Fig. 187, Pl. XXVI.)

Found in great social groups in fresh water.

VORTICELLA QUADRANGULARIS (?) S. K.

Figure 188, Plate XXVI, illustrates the largest species of *Vorticella* that has been observed in this state. Body greatly elongated, fully three times as long as broad, angular in contour, anterior margin slightly dilated. Pharynx very large and conspicuous. Surface transversely striate. Stalk thick and short, about twice the length of the body.

Length of body, 200 microns.

The form illustrated is classified here with some doubt as to its true identity. The organism was found in fresh water. Solitary in its habits.

VORTICELLA sp.

Figure 192, Plate XXVI, represents a species rarely found in this state. Body somewhat spherical when extended. Anterior border dilated to a considerable degree. Surface striate transversely. Stalk slender, three or four times as long as the body.

Length of body, 50 microns.

Habitat, fresh water, in small social groups.

VORTICELLA FLUVIATILIS From.

Body ovate, truncate anteriorly, with a deep concave depression in the anterior border, where the stalk is produced. Surface smooth. Stalk three or four times the length of the body.

Length of body, 40 microns. (Fig. 186, Pl. XXVI.)

Habitat, fresh water. Solitary in habits. Observed in Keokuk county.

VORTICELLA CONVALLARIA Linn.

Body elongate, twice as long as broad, conical, slightly dilated anteriorly. Surface transversely striate. Stalk four or five times as long as the body.

Length of body, 100 microns. (Fig. 190, Pl. XXVI.)

Social in habits. Found in infusions of pond water. The pedicle of this species is frequently the support for the collared flagellate, *Monosiga steinii*.

VORTICELLA ELONGATA From.

Body elongate, two and one-half times as long as broad, wider anteriorly, with margin slightly dilated. Surface transversely striate. Stalk short, not often more than twice the length of the body.

Length of body, 80 microns. (Fig. 189, Pl. XXVI.)

Habitat, stagnant water. Solitary in habits.

VORTICELLA sp.

Figure 193, Plate XXVI, illustrates a very small species of *Vorticella* sometimes found in this state.

Body elongate-ovate, wider centrally, anterior border slightly dilate. Tapering from the middle to the narrow posterior extremity. Surface smooth. Endoplasm transparent. Stalk slender, about three times the length of the body.

Length of body, 30 microns.

Habitat, stagnant water. Solitary.

CARCHESIUM Ehrenberg.

Resembling *Vorticella* but forming branched colonies with a common pedicle, the central muscle fibre being interrupted at the union of the stalk of each zoöid and the branch allowing the zoöid and its pedicle to contract independently.

CARCHESIUM POLYPINUM Linn.

Bodies somewhat pyriform, the anterior border dilated. An erect common pedicle, bearing many branches at its extremity, to which in turn are attached the pedicles of the individual zoöids. Surface of bodies smooth. Nucleus band-like, curved.

Length of zoöids, 50 microns.

Height of colony, 3,000 microns. (Figs. 194–196, Pl. XXVII.)

Figure 194 represents but a small fragment of a colony of this species. In some instances these tree-like clusters are built up to a height exceeding an eighth of an inch and contain several hundreds of zoöids.

Figure 195 illustrates a single zoöid of this species.

From a physiological point of view *Carchesium polypinum* is of no little interest. It is known what an essential part the nucleus plays in the normal activities of the living cell and in this species is illustrated the effect upon the nuclear elements of imperfect nutrition.

Miss M. Greenwood, in *The Journal of Physiology*, Vol. XX, pp. 427–454, sets forth the morphological elements enclosed by the nuclear membrane of the nucleus of *Carchesium polypinum* as being the "nucleochyme" or fluid medium, the "microsomes" or small granule-like bodies densely scattered through the "nucleochyme" and the "macrosomes" or larger masses, deeply staining with certain dyes usually oval or rounded and which may be scattered or arranged in a median line throughout the length of the curved nucleus. Miss Greenwood found that after feeding *Carchesium* on an insoluble substance such as boiled white of egg the usually deeply and uniformly staining macrosomes took on a vacuolated appearance, some of them being represented by mere shells with clear interiors. The conclusion drawn by Miss Greenwood was that the normal activity caused a drain on the organism which was not offset by sufficient repair, due to the lack of nutrition, the result being shown in the more fluid character of the macrosomes.

Somewhat similar phenomena with respect to the nucleus of *Carchesium polypinum* has come under my observation. Late in December, 1904, individuals of this species were obtained from the under side of stones in a pool near Iowa City. They appeared as minute white masses, just visible to the unaided eye, and when

taken from the ice-water were and probably had been for a long time in a state of inactivity.

On fixing and staining these individuals it was found that the macrosomes were condensed into rounded masses, usually from six to twelve being arranged in a median row throughout the length of the nucleus. Moreover, the macrosomes were highly vacuolated, Figure 196 being drawn from a permanent preparation.

It is probable that these individuals, taken from such an environment as they were, had received little or no nutrition for some time, the physiological result of this loss being manifested in the vacuolated and more fluid condition of the macrosomes.

Sometimes *Carchesium polypinum* is the temporary host of *Amphileptus meleagris*, as before described. The habitat of *Carchesium polypinum* is fresh water, often being found in running streams, attached to the under side of rocks, leaves, etc.

EPISTYLIS Ehrenberg.

Zoöids somewhat similar to *Vorticella*, usually forming a dichotomously branched colony, with a stout non-contractile stalk.

EPISTYLIS FLAVICANS Ehr.

Zoöids campanulate, greatly dilated anteriorly when extended. Five or six circles of strong cilia about the ciliary disk. Stalk dichotomously branching and rigid, at least in the young forms. Bodies usually pale yellow in color, transversely striate. Nucleus band-like, curved.

Length of zoöids, 200–350 microns.

The zoöids of this species are among the largest and perhaps the most strongly ciliated of the genus.

Figure 202, Plate XXVIII, illustrates a colony with a rigid, erect pedicle, and but two zoöids, which indicates a very young stage. In old forms the stalk loses its rigidity and the whole colony falls down in a tangled mass. Kent reports that lack of food will transform an erect colony into a decumbent one within a few hours, and specimens taken from fresh water near Iowa City in the early winter were all in this condition, probably due to the same cause.

Reproduction by longitudinal fission continues even after the

colony falls down, the physiological condition apparently resulting in a weakening of the supporting pedicels and branches. Fig. 203, Pl. XXVIII, from a prepared mount, shows the ciliary convolutions of the oral system. As in other colonial forms of this family the zoöids may develop a posterior wreath of cilia, break away from their pedicles and, each leading an independent life for a time, may ultimately settle down in more favorable conditions and begin the development of a new colony.

The species is not uncommon in the waters of this state, usually found abundantly in small running streams or fresh water pools, attached to leaves, sticks, rocks, etc.

EPISTYLIS ARTICULATA From.

Zoöids elongate, dilated anteriorly, tapering toward the posterior extremity; surface smooth. Stalks short and stout, longitudinally striate, dichotomously branching, with an articulation near the middle of the main pedicle and sometimes one or two between each bifurcation of the branches.

Length of zoöids, 42 microns.

Figure 197, Plate XXVII, represents this species, being a young colony with two zoöids. Figure 198 illustrates the colony in the process of growth by longitudinal division, the zoöids being contracted.

Figure 199 pictures a single zoöid in a contracted state, oval in form, with a concave depression in the anterior border, but lacking the annular furrows of the posterior region which are present in *Epistylis plicatilis*. The colonies are small, containing not more than a dozen zoöids, and the more frequent number is from four to six.

Found in Johnson county, attached to rocks in a small running stream.

EPISTYLIS PLICATILIS Ehr.

Zoöids elongate, conical, with anterior border dilated and ciliary disc elevated. Surface smooth; when contracted, deep annulations occur in the posterior region while the anterior border is often drawn into a minute cylindrical process. Stalk slender, dichotomously branched, secondary divisions very long.

Nucleus band-like, curved.

Length of zoöids, 75–100 microns. (Figs. 200–201, Pl. XXVIII.)

Epistylis plicatilis is one of the abundant species of this genus found in running streams and fresh water pools in Johnson county. It may be found on the under side of stones, leaves, etc., often associated with *Epistylis articulata*. The suctorian *Podophrya quadripartita* may be attached to the branches of this species in great numbers; also specimens observed by the writer bore another minute species of *Epistylis* not illustrated and not identified.

Figure 200 represents a portion of a colony. Figure 201 represents a single zoöid contracted.

VAGINICOLA Lamarck.

Body elongate, somewhat cylindrical, inhabiting a vase-shaped lorica. Ciliary and oral systems similar to those of *Vorticella*.

Lorica transparent and sessile.

VAGINICOLA sp.

Lorica cylindrical, not quite twice as long as broad, wider and broadly rounded posteriorly. Anterior extremity truncate, with a conspicuous, cleft-like notch in the margin. Character of body undetermined.

Length of lorica, 120 microns. (Fig. 204, Pl. XXVIII.)

Members of this genus are apparently rare in this state, the individual figured being the only one observed, and that under conditions which prevented a study of the extended body. The organism was fixed with other Infusoria before it came under my observation. Two contracted bodies indicates that longitudinal division had recently occurred, both individuals being yet within the lorica.

Found in Johnson county. Habitat, fresh water, among algæ.

COTHURNIA Ehrenberg.

Body as in *Vaginicola*, inhabiting a lorica with a short stalk.

COTHURNIA IMBERBIS Ehr.

Length of lorica about one and one-half times the breadth, wider posteriorly, the anterior border evenly truncate. Stalk short. Body, when fully extended, projecting but little beyond the margin of the lorica. Nucleus band-like, short and curved.

Length of lorica, 100 microns. (Fig. 205, Pl. XXVIII.)

A very short stalk is present in this species, sometimes slightly curved, but often represented only by a knob-like process.

This species differs from *Cothurnia ovata* chiefly in the slightly everted margin of the lorica of the latter and the greater extension of the body. In *Cothurnia imberbis* the dilated ciliary border is barely pushed beyond the margin of the lorica.

Reproduction takes place by longitudinal division, the daughter-cell being shown in the plate figure in a contracted condition.

Found in fresh water, attached to aquatic plants. Distribution is very general.

COTHURNIA CURVA Stein.

Lorica about twice as long as broad, anterior extremity slightly curved. Stalk short and thick, sometimes curved. Lorica transparent or opaque. Body slender, extending but little beyond the margin of the lorica.

Length of lorica, including stalk, 110 microns.

The opaque phase of the lorica represented by Fig. 206, Pl. XXVIII, indicates the mature form and is usually reddish-brown in color. Transparent or young individuals are often associated with the adult specimens. Found in fresh water, but not so abundant as *Cothurnia imberbis*.

Sub-class, SUCTORIA.
Family, PODOPHRYIDÆ.

SPHÆROPHRYA C. & L.

Usually spherical, with capitate tentacles produced from all parts of the periphery. Never producing a stalk. Sometimes parasitic within other Protozoa.

SPHÆROPHRYA MAGNA Maupas.

Body spherical. Tentacles scattered irregularly over the surface. Endoplasm granular. Nucleus spherical. Contractile vesicle usually single.

Diameter of body, 36 microns. (Fig. 207, Pl. XXIX.)

Found in diatomaceous ooze from a small stream in the vicinity of Iowa City. The tentacles, which are usually equal in length to the diameter of the body, are effectively used to catch small,

free-swimming ciliates, transferring their contents to the Suctorian's body by means of the central axial protoplasmic current.

Reproduction takes place by transverse division, and on one occasion an internal embryo was observed to break from the parent body, being entirely ciliate, but so minute and rapid in its movements that no satisfactory study of it could be made.

PODOPHRYA Ehrenberg.

Spherical, oval or elongated pear-shaped. Usually attached by a rigid stalk. Tentacles mostly capitate either in fascicles or distributed irregularly over the periphery. Nucleus and contractile vesicles conspicuous.

PODOPHRYA FIXA Müll.

Body spherical, attached by a slender but rigid stalk. Tentacles capitate, slender, and scattered over the surface of the body, often not greater in length than the diameter of the body. Nucleus oval, central or sub-central. Contractile vesicles sometimes two in number.

Diameter of body, 55 microns. (Figs. 208–210, Pl. XXIX.)

Found in fresh water among algæ, usually attached to aquatic plants by means of the stalk, which rarely exceeds in length the diameter of the body. When the water becomes slightly stagnant the individuals rapidly pass into the encysted state, the cyst being very characteristic of the species. Beginning with the stalk itself the outer surface gradually becomes indurated and sharp annular ridges make their appearance, there being from four to six in the complete cyst. The pedicle in the completely encysted form has assumed the appearance of a short, curved, caudal appendage.

Reproduction commonly takes place by transverse division. Fig. 208 illustrates a normal individual. Fig. 209 represents the beginning of the encystment, while Fig. 210 pictures the completed cyst. Small holotrichous forms serve as the principal food of this organism.

PODOPHRYA QUADRIPARTITA C. & L.

Body elongate, pear-shaped, the anterior extremity produced into four lobe-like regions from each of which proceeds a fascicle

of capitate tentacles. Posteriorly the body gradually tapers toward the point of attachment to the pedicle. The pedicle is slightly expanded at the point of union with the body. Nucleus elongate or oval. Contractile vesicles usually more than one.

Length of body, 100–200 microns. (Figs. 211–213, Pl. XXIX.)

This species has been found abundantly, attached to *Epistylis plicatilis*, which has been obtained from the under side of stones in small running streams. *Podophrya quadripartita* may also be found attached to other species of *Epistylis*. The pedicle is four or five times the length of the body and in appearance closely resembles a branch of the host which serves as its support. With the body of the Suctorian extending slightly beyond the border of the zoöids of the *Epistylis*, it can readily be seen that some minute organisms, drawn by the powerful currents produced by the zoöids of the Vorticellan, may find lodgment against the suckers of *Podophrya*.

Figure 211 illustrates a typical normal individual. Fig. 212 represents a branch of *Epistylis* with several individuals of this species attached.

Reproduction takes place by the development and liberation of internal embryos. Fig. 213 is reproduced from an individual killed with osmic acid and stained with carmine, showing what is probably an internal embryo previous to its extrusion.

Family, ACINETIDÆ.

ACINETA Ehrenberg.

Body inhabiting a lorica which is produced posteriorly into a rigid stalk. Tentacles capitate, in groups or scattered.

Two species have been observed in this state, neither of which I have been able to identify.

ACINETA sp.

Lorica spherical, produced anteriorly into a short, thick stalk. Body spherical, almost completely filling the lorica. Tentacles in two antero-lateral groups. Nucleus spherical, central. Contractile vesicle single, lateral.

Height of the lorica, 78 microns. Fig. 214, Pl. XXIX.)

Found in fresh water in Johnson county. Stalk shorter than the diameter of the body.

ACINETA sp.

Lorica somewhat spherical, produced posteriorly into a stalk which exceeds in length the diameter of the body. Body in close contact with the inner surface of the lorica. Four groups of capitate tentacles. Nucleus spherical, central. Contractile vesicle single.

Height of the lorica, 120 microns. (Fig. 215, Pl. XXX.)

Found in fresh water in Johnson county. Each fascicle of tentacles arises from a base which is apparently an outpushing of the body through an opening in the lorica.

HALLEZIA Sand.

Sand founded this genus chiefly upon the following characters: No lorica or stalk, sessile. Tentacles confined to the anterior end.

HALLEZIA BUCKEI S. K.

"Body elongate, slender, sub-cylindrical, bearing two antero-lateral fascicles of distinctly capitate tentacles; not possessing a distinct pedicle, but affixed basally by a simple contracted sucking disc; contractile vesicle anteriorly located; endoplasm sub-central.

"Dimensions unrecorded. Habitat, fresh water."

The above description is from Kent's "Manual of the Infusoria," p. 822.

PODOPHRYA COMPRESSA Nutting.

"Body illoricate, quadrate, wider anteriorly; length from two to five times the greatest width; compressed, about three times as wide as thick; the antero-lateral corners occupied by rounded prominences each bearing a fascicle of many suctorial tentacles which, when fully extended, are more than half the length of the body and spiral or spirally marked when retracted; posterior portion of the body rapidly narrowing to meet the very short, thick pedicle, which is furnished with a sucking disk at its distal end; parenchyma densely and evenly granular; contractile vesicle single, anterior; endoplast oval.

"Length of body, 1-277" to 1-140". Habitat, fresh water."

This description is taken from *The American Naturalist;* Vol. XXII, p. 13.

The chief difference between *Podophrya buckei* S. K. and *Podophrya compressa* Nutting is in the shape of the body. Sand has found all transitional forms between the cylindrical and greatly compressed body and therefore concludes that *Podophrya buckei* S. K. and *Podophrya compressa* Nutting are identical. For the reception of this and closely allied forms he has instituted the genus *Hallezia* and the species described above is known as *Hallezia buckei* S. K.

Since the Iowa form described by Nutting was of the compressed variety, and the species not having come under my observation, Figs. 216–218, Pl. XXX, are reproduced from *The American Naturalist*. Fig. 216 is a view of the broad side of the organism, while Fig. 217 illustrates the form from a lateral view point. Fig. 218 represents the beginning of reproduction, the tentacles being retracted and the internal embryos forming, which are finally extruded. Each embryo becomes a free-swimming organism for a period and then, settling down, attaches itself and rapidly developes into the adult.

For a detailed study of the species, its habits and life history, see *The American Naturalist*, Vol. XXII, p. 13.

Family, DENDROSOMIDÆ.

TRICHOPHRYA C. & L.

Irregular in shape, ovate or elongate. Tentacles usually distinctly capitate, scattered or in groups. No supporting stalk or lorica present.

TRICHOPHRYA SINUOSA Stokes.

Body irregular in shape, with marginal lobes. Tentacles long, capitate, extending in clusters from the lobes. Nucleus band-like, with ramifying branches. Contractile vesicles one or more.

Length of body, 155–200 microns. (Fig. 219, Pl. XXX.)

This species, first discovered by Dr. Stokes of New Jersey, has been observed in several localities in Iowa, being found in fresh water among algæ and other aquatic plants.

The organism is somewhat amœba-like, the marginal lobes, of which there may be as many as nine, having in some degree the power of extension and contraction resembling lobose pseudopodia

without a differentiation between endoplasm and ectoplasm. From these lobes are thrust out, often to a great distance, slender and distinctly capitate tentacles.

Dr. Stokes did not observe the nucleus, which is usually invisible without the aid of reagents. It is, however, band-like, with its ramifying branches extending toward and even into the bases of the marginal lobes. In these regions metabolic changes probably take place rapidly, since the protoplasm within the lobes may readily be seen to be in violent agitation as the tentacles are extended and withdrawn. In *Trichophrya sinuosa* there is what seems to be an example of the disposition of the nucleus of the animal cell where it can best influence metabolism. The specimens observed in this state were much greater in size than the dimensions given by Dr. Stokes.

SOME PUBLICATIONS

Of Value to One Pursuing a Systematic Study of the Protozoa.

Butschli—Protozoa. In Bronn's Klassen und Ordnungen des Thierreichs - - - - - 1883–1888

Calkins—The Protozoa - - - - - - - 1901

Conn—A Preliminary Report on the Protozoa of the Fresh Waters of Connecticut - - - - - 1905

Kent—A Manual of the Infusoria - - - 1880–1882

Note—The classification employed by Kent is not accepted now.

Leidy—North American Rhizopods - - - - 1879

Palmer—Delaware Valley Forms of Trachelomonas - 1905

Roux—Faune Infusorienne Des Eaux Stagnantes Des Environs De Genève - - - - - - - 1901

Stokes—A Preliminary Contribution Toward a History of the Fresh Water Infusoria of the United States 1888

INDEX.

PLATE I.

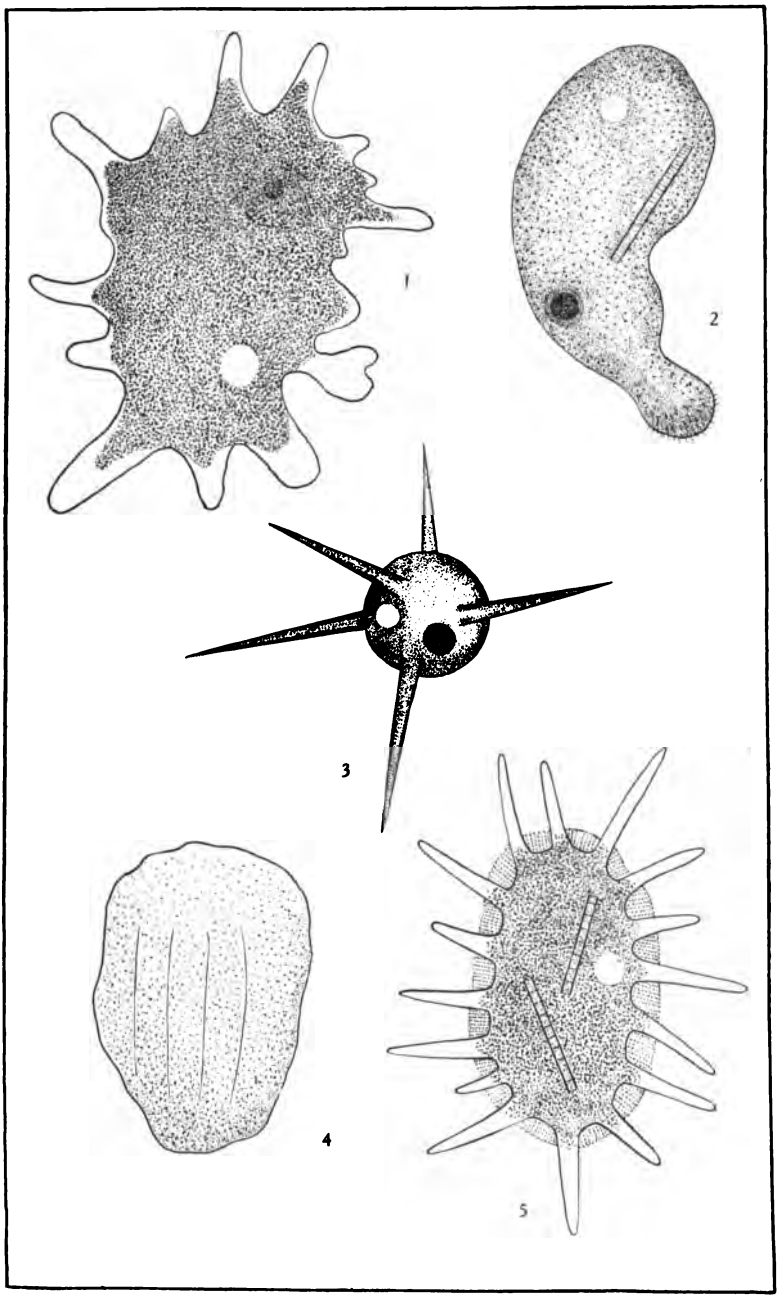

1
2
3
4
5

PLATE II.

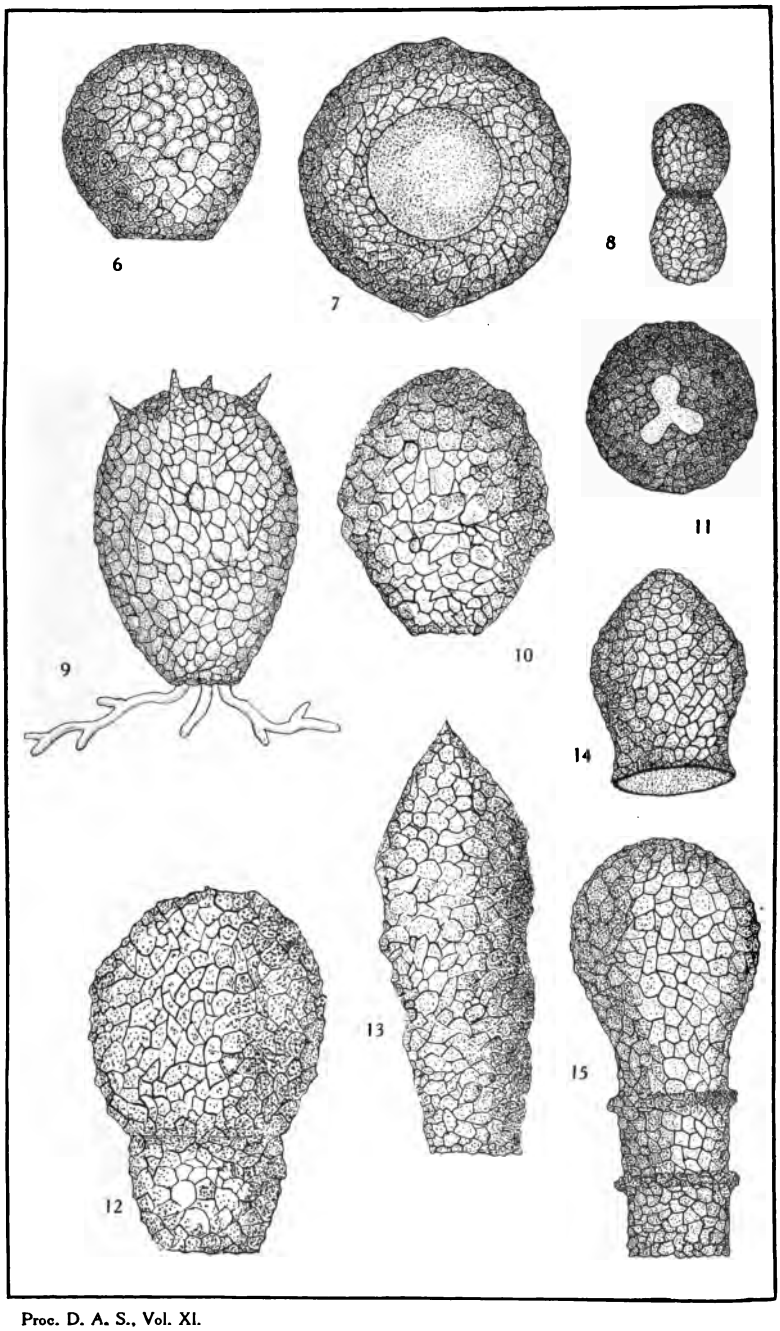

6
7
8
9
10
11
12
13
14
15

PLATE III.

PLATE III.

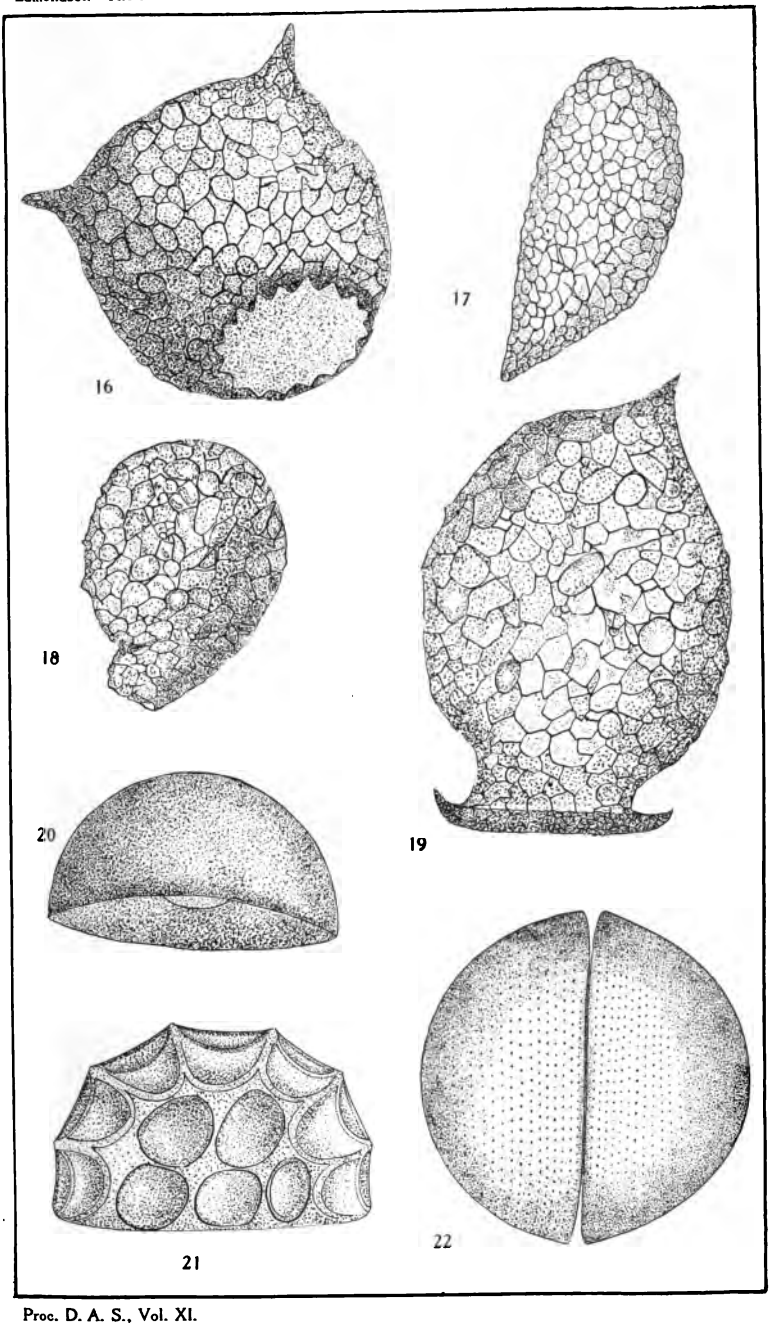


PLATE IV.

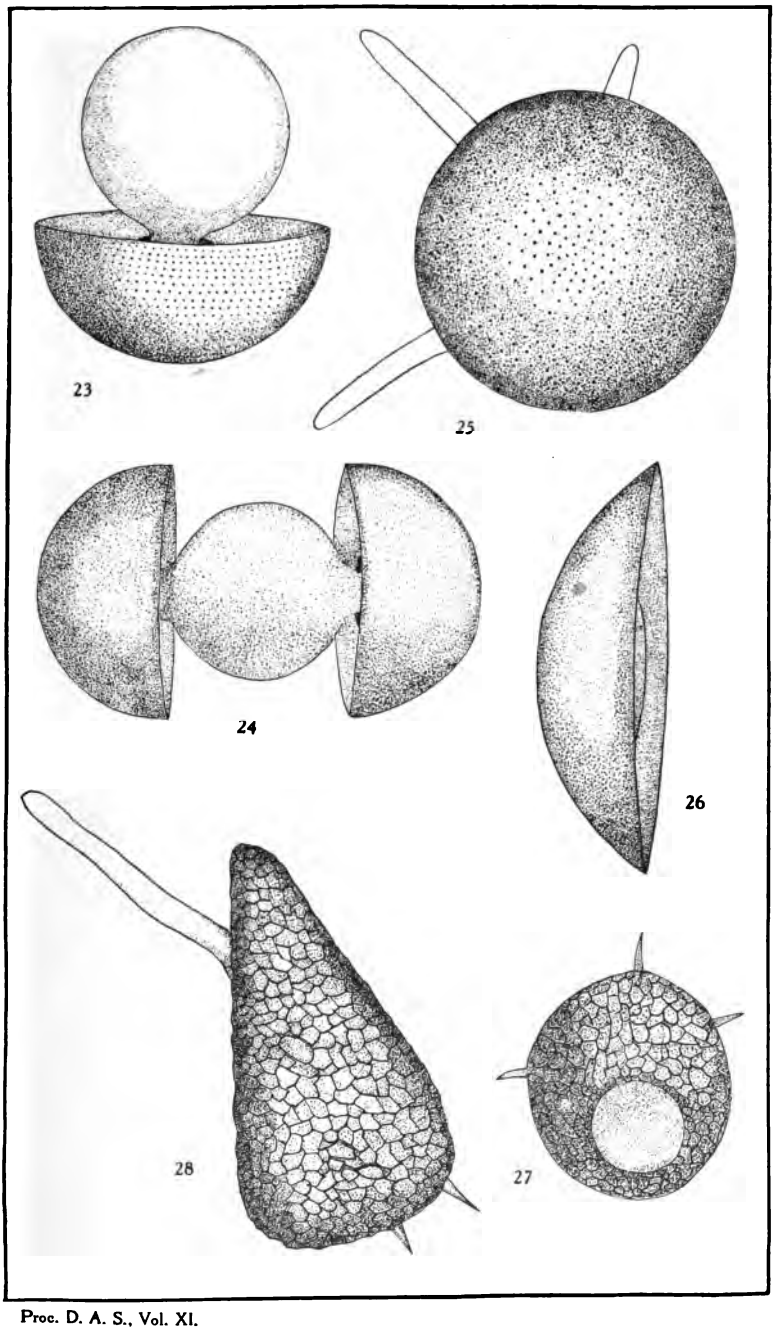

23
25
24
26
28
27

PLATE V.

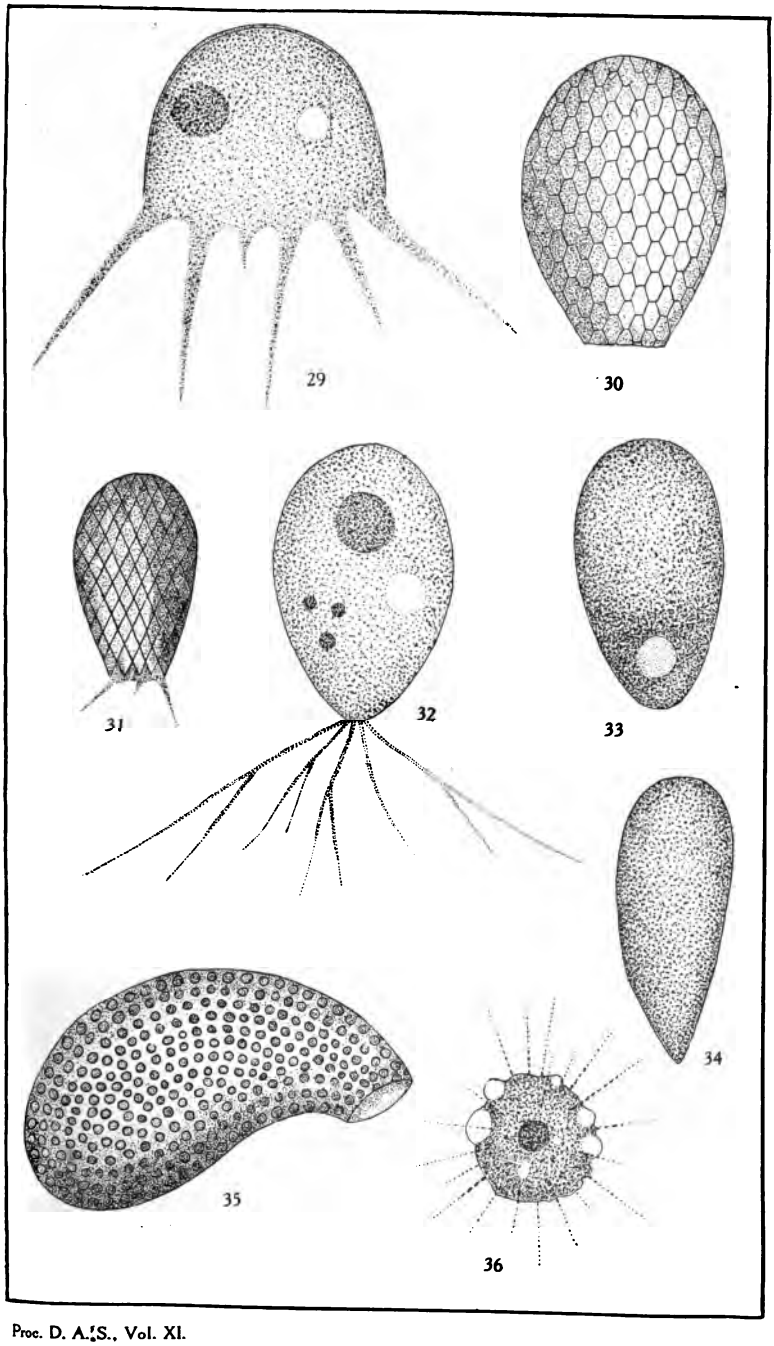

29
30
31
32
33
34
35
36

PLATE VI.

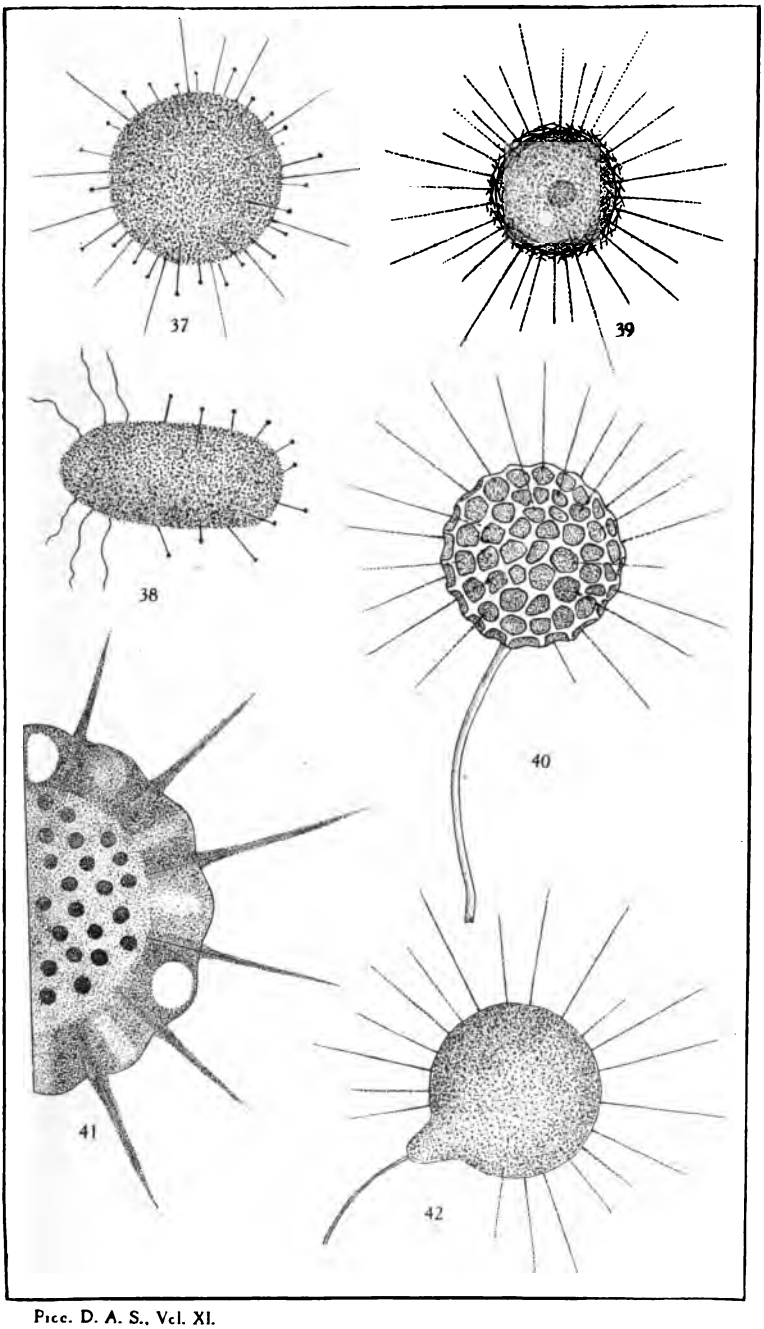

37
39
38
40
41
42

PLATE VII.

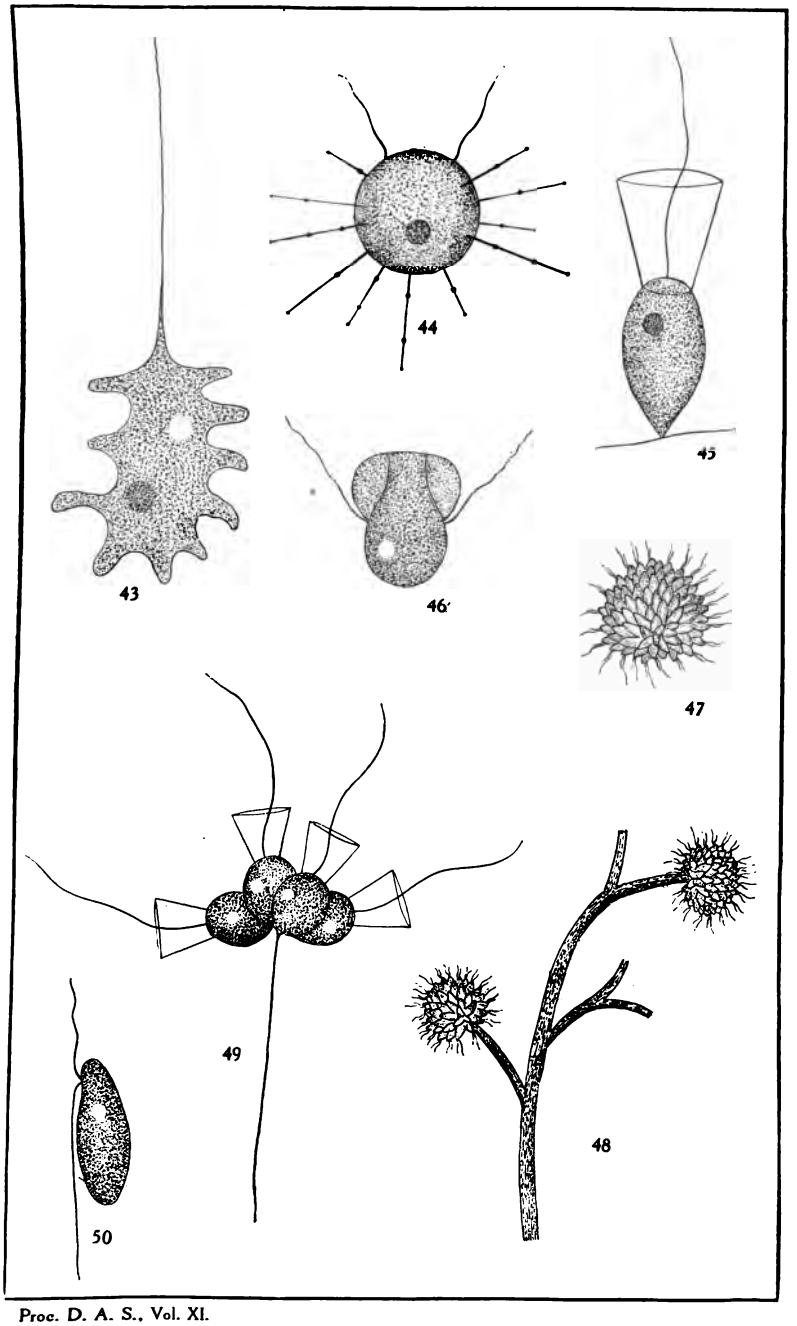

43
44
45
46
47
48
49
50

PLATE VIII.

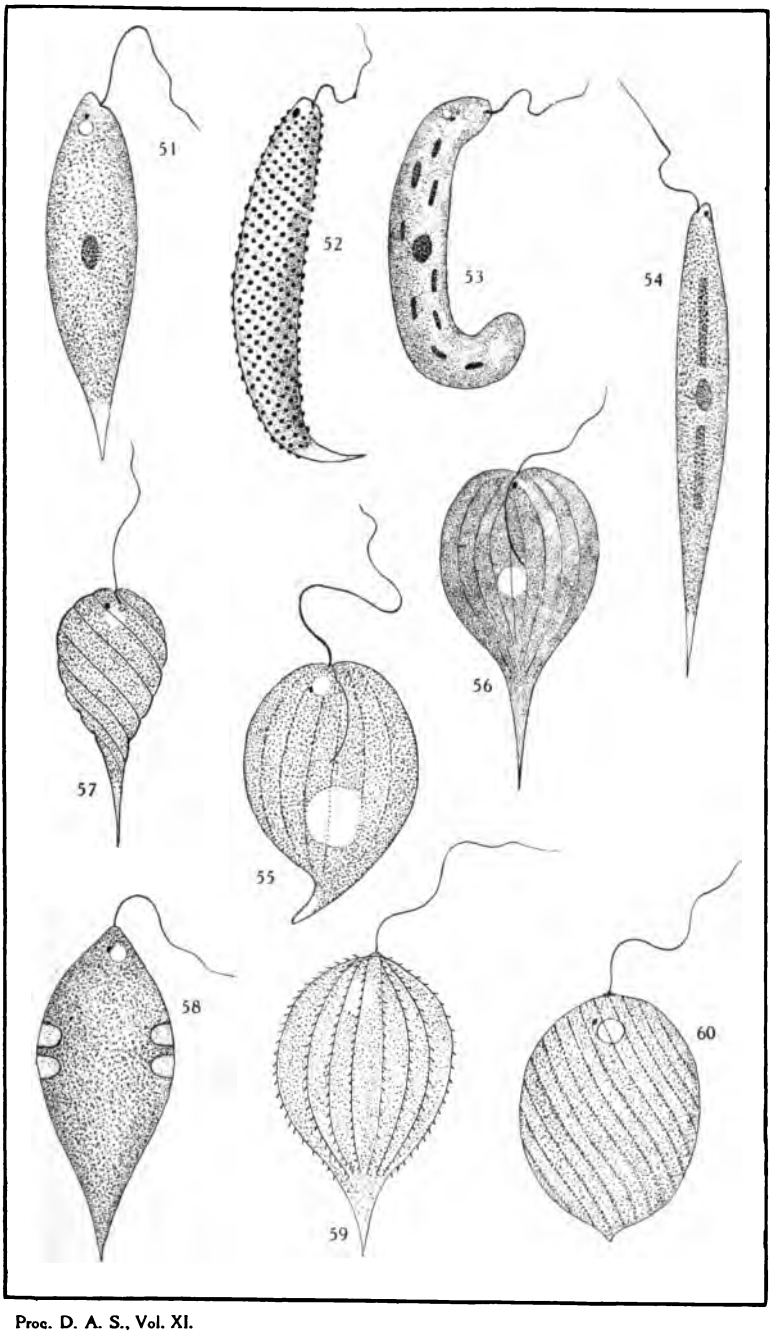

51
52
53
54
56
57
55
58
59
60

PLATE IX.

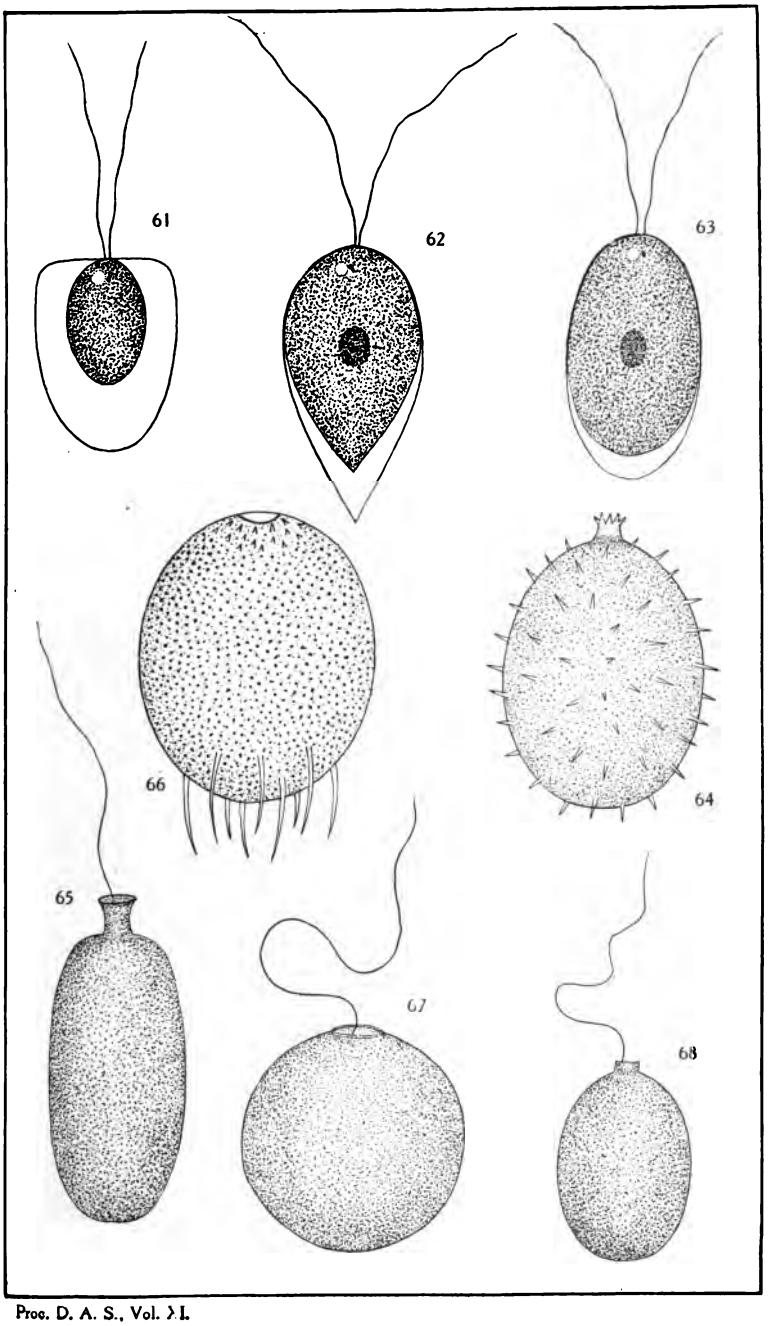

61
62
63
66
64
65
67
68

PLATE X.

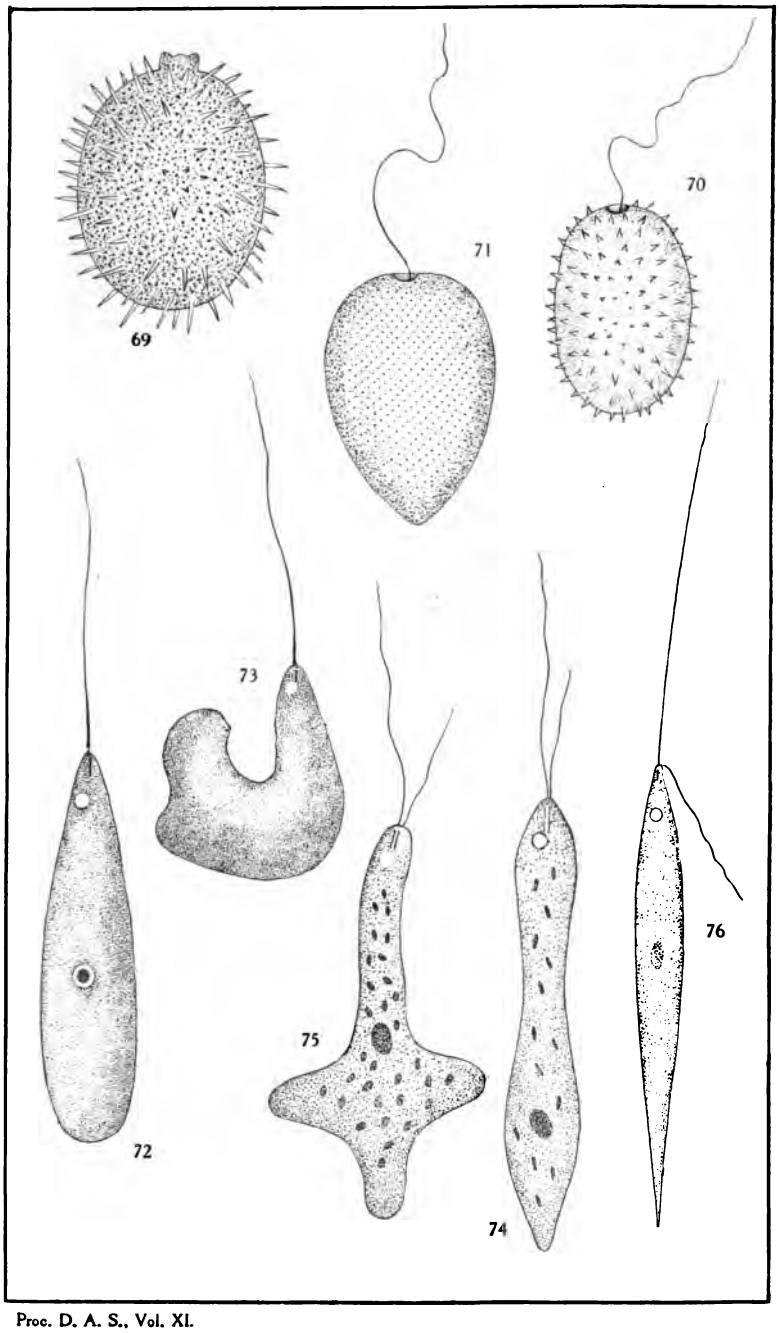

69
70
71
72
73
74
75
76

PLATE XII.

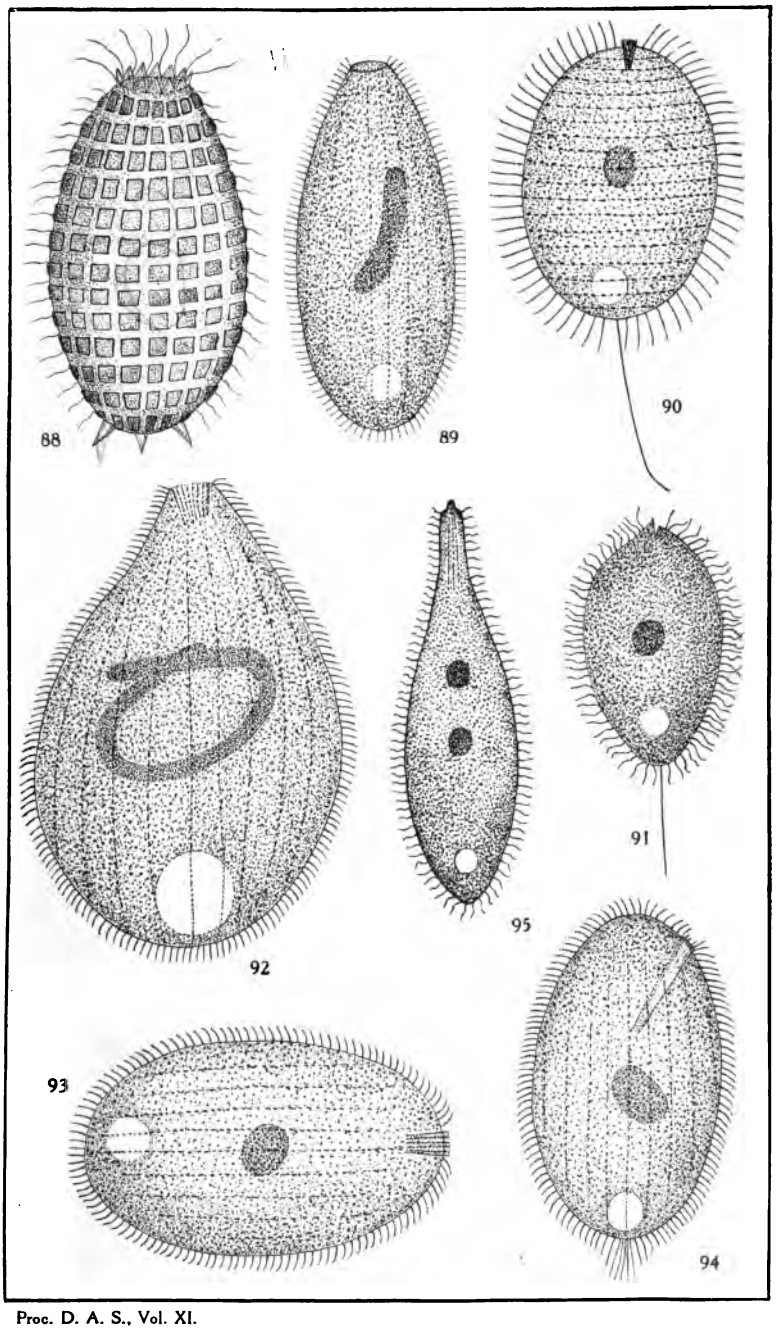

88
89
90
91
92
93
94
95

PLATE XIII.

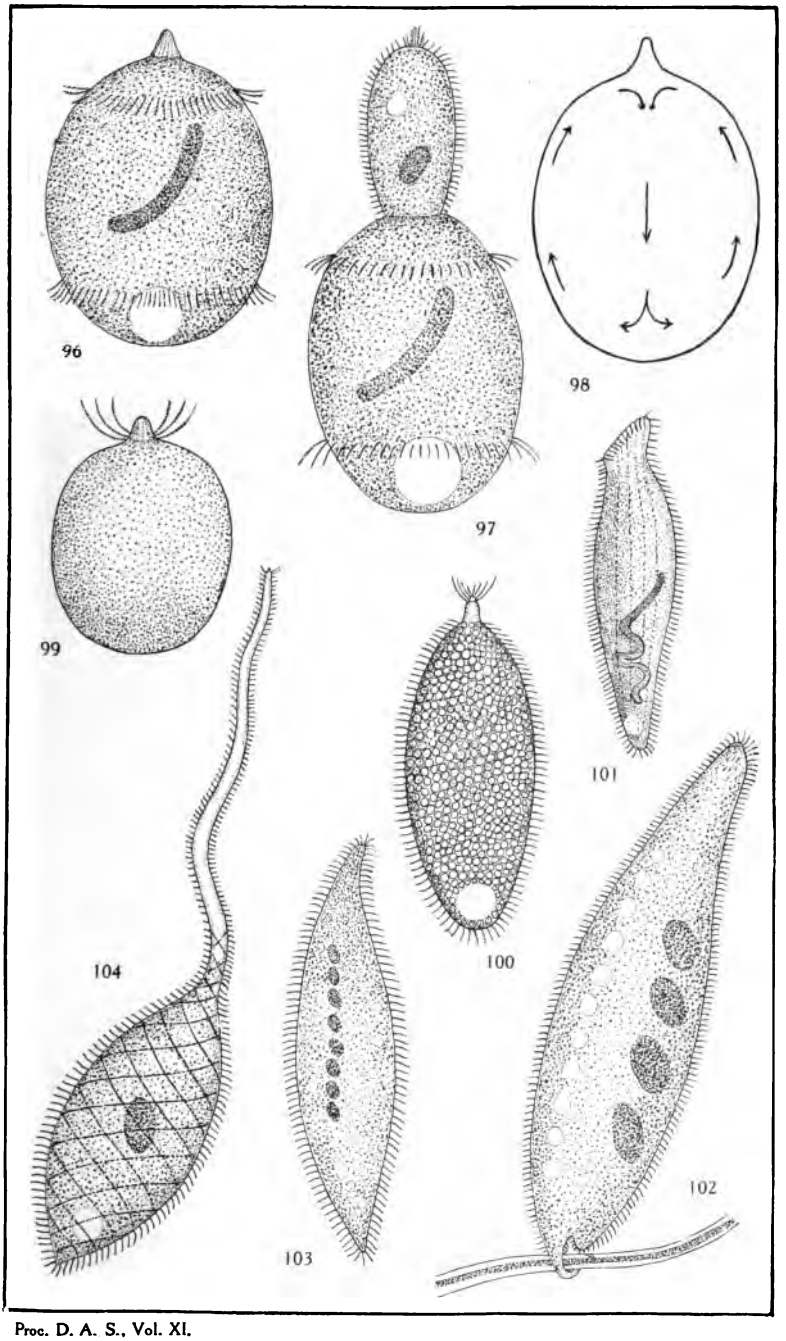

96
97
98
99
100
101
102
103
104

PLATE XIV.

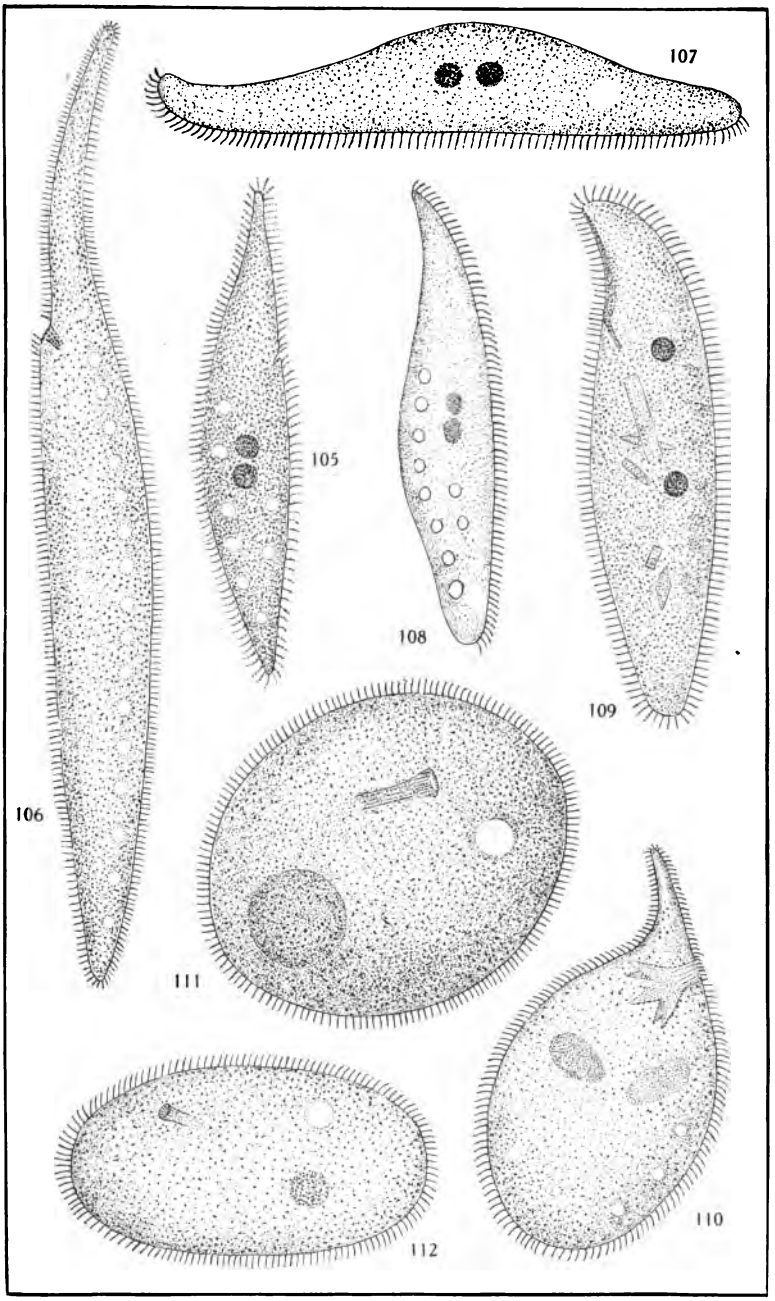

107
105
108
109
106
111
110
112

PLATE XV.

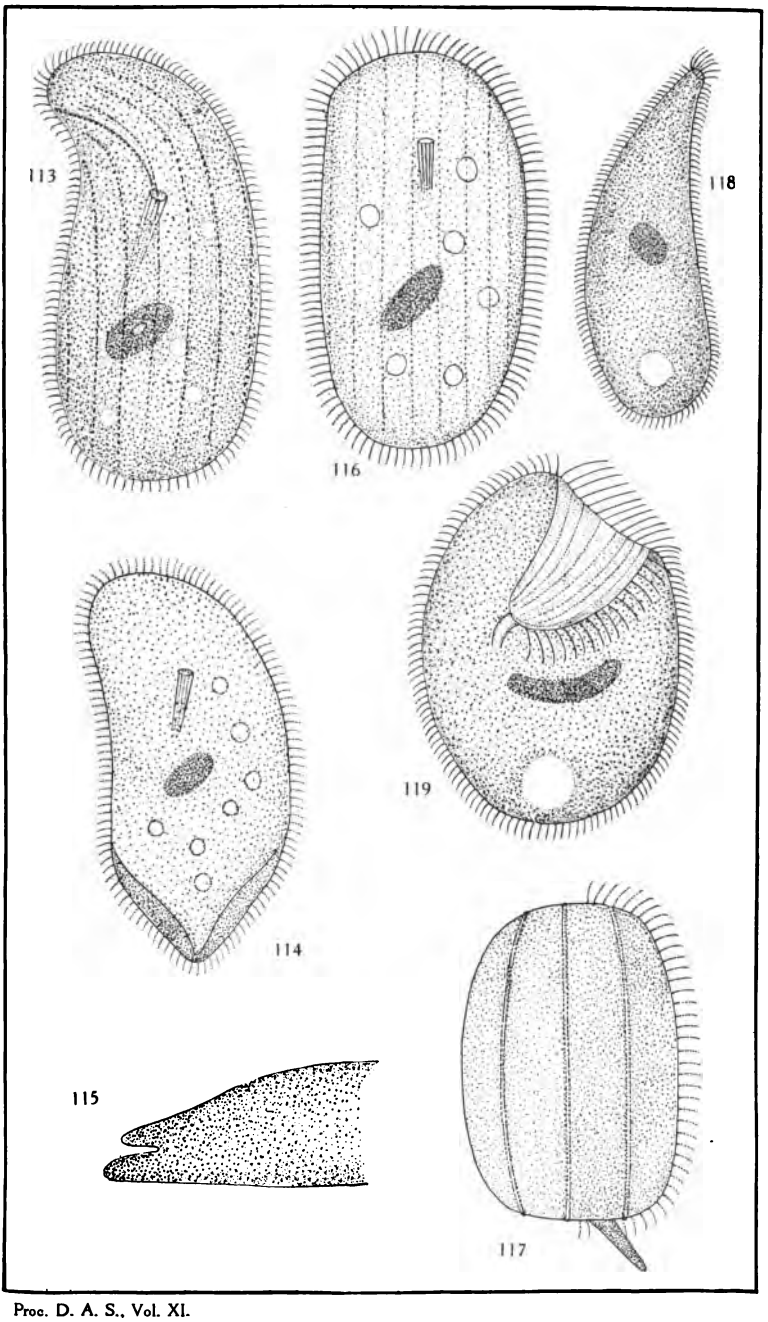

113
116
118
119
114
115
117

PLATE XVI.

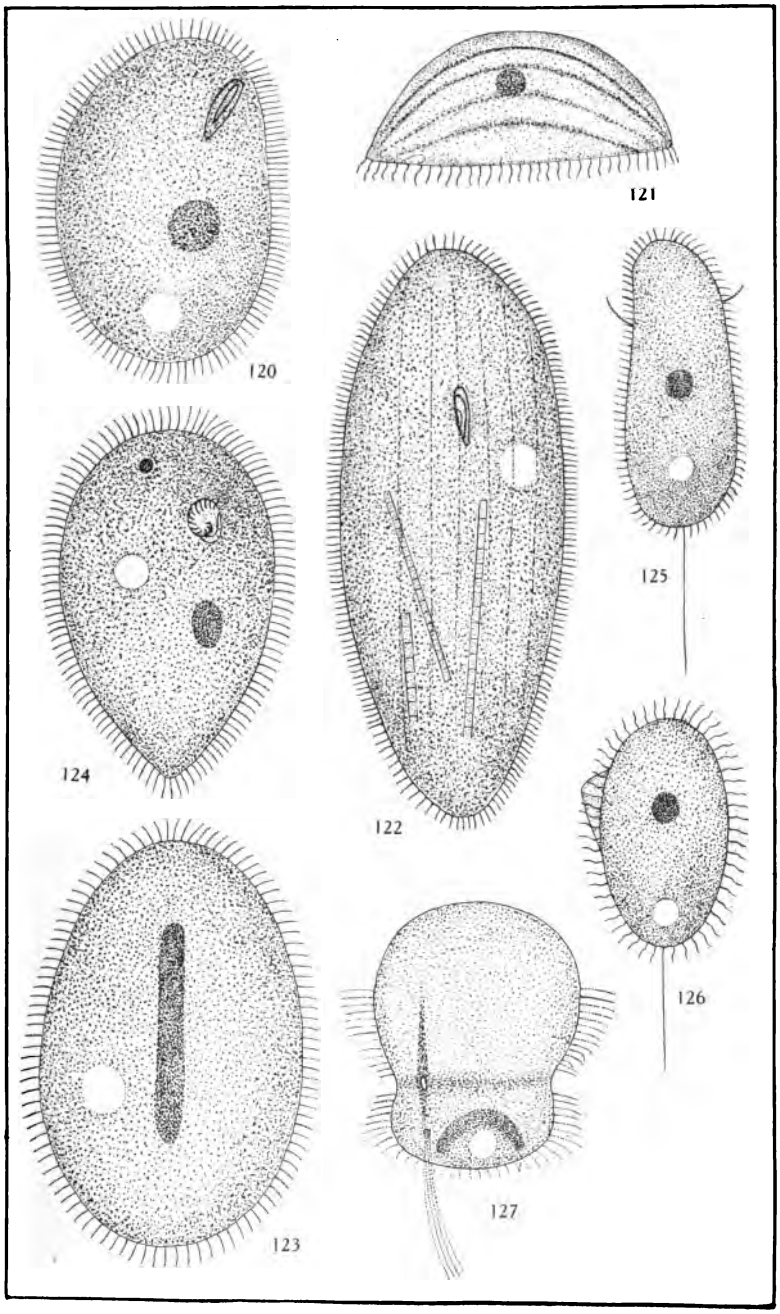
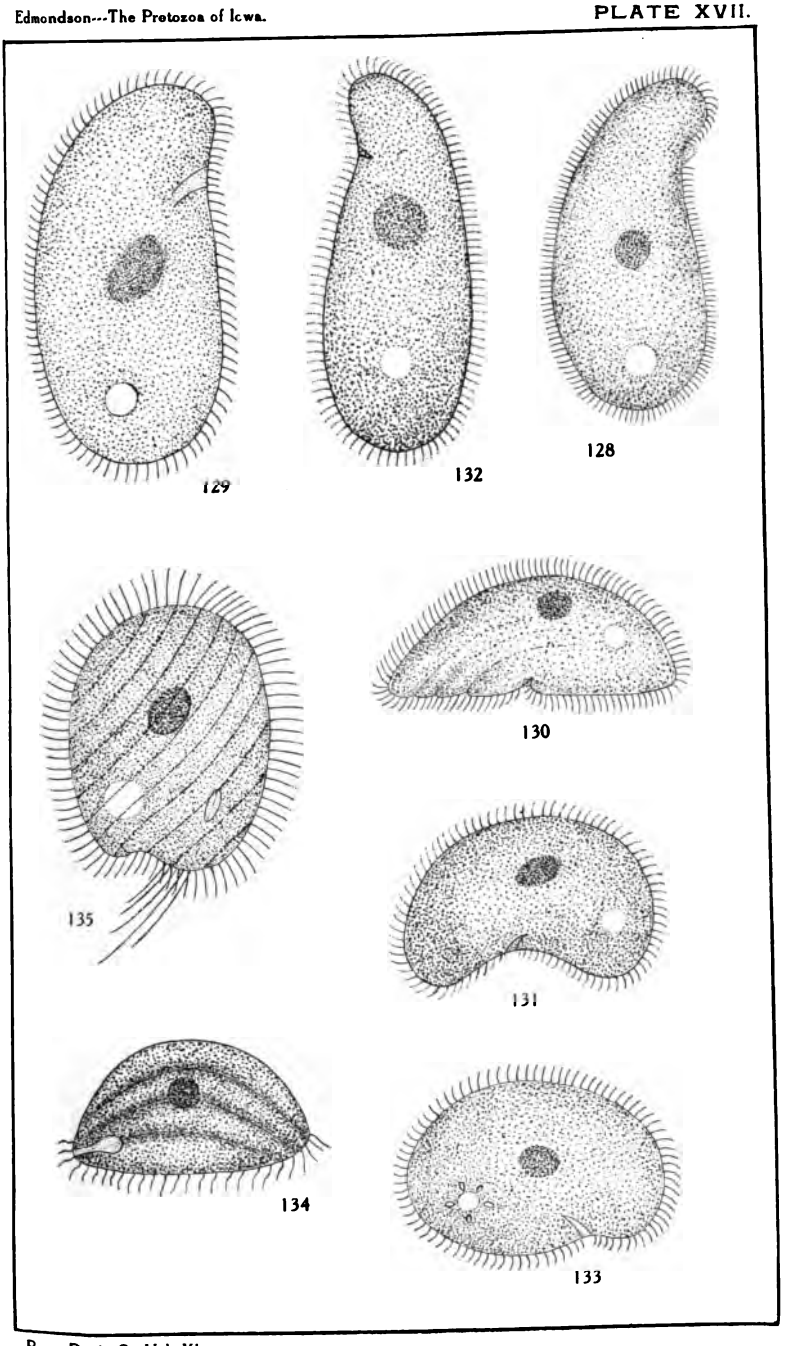

120
121
122
123
124
125
126
127

PLATE XVII.

PLATE XVII.



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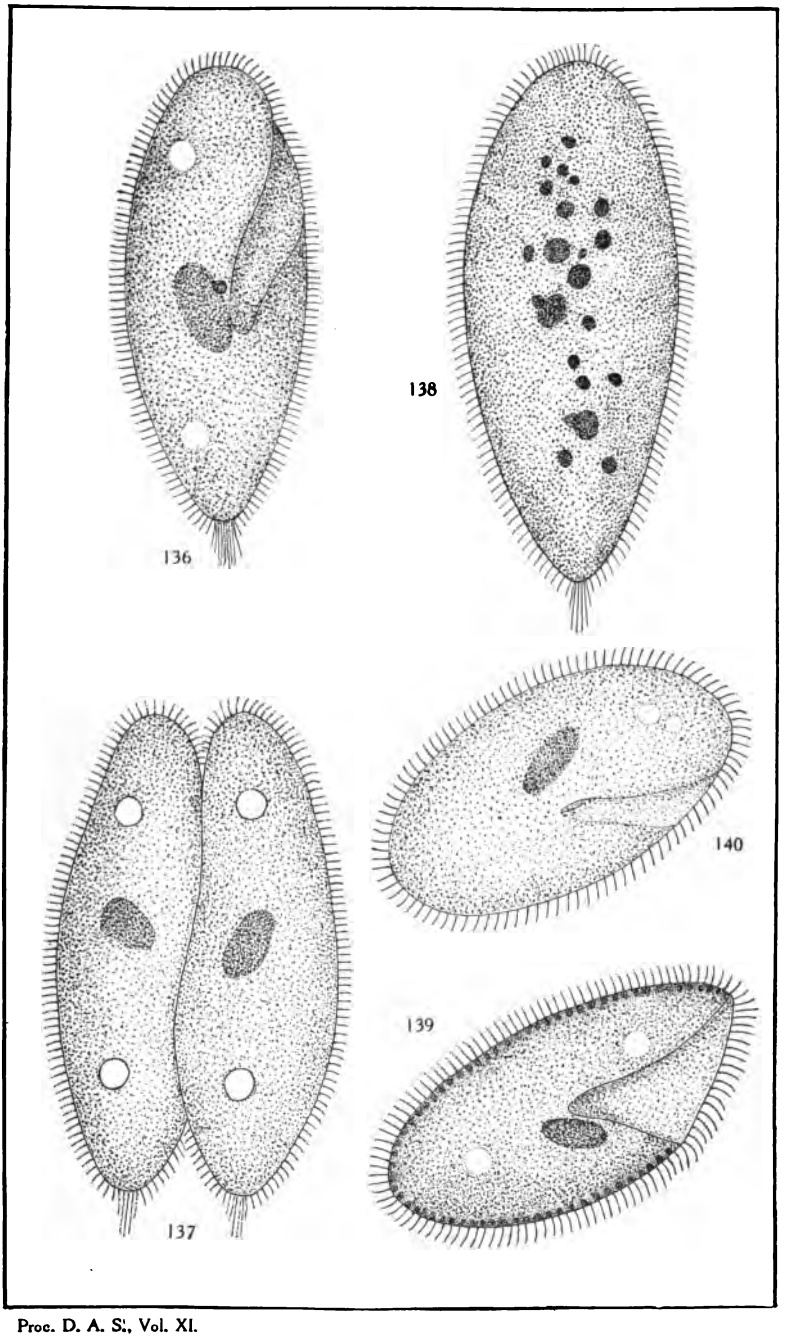
136
138
137
140
139

PLATE XIX.

PLATE XIX.

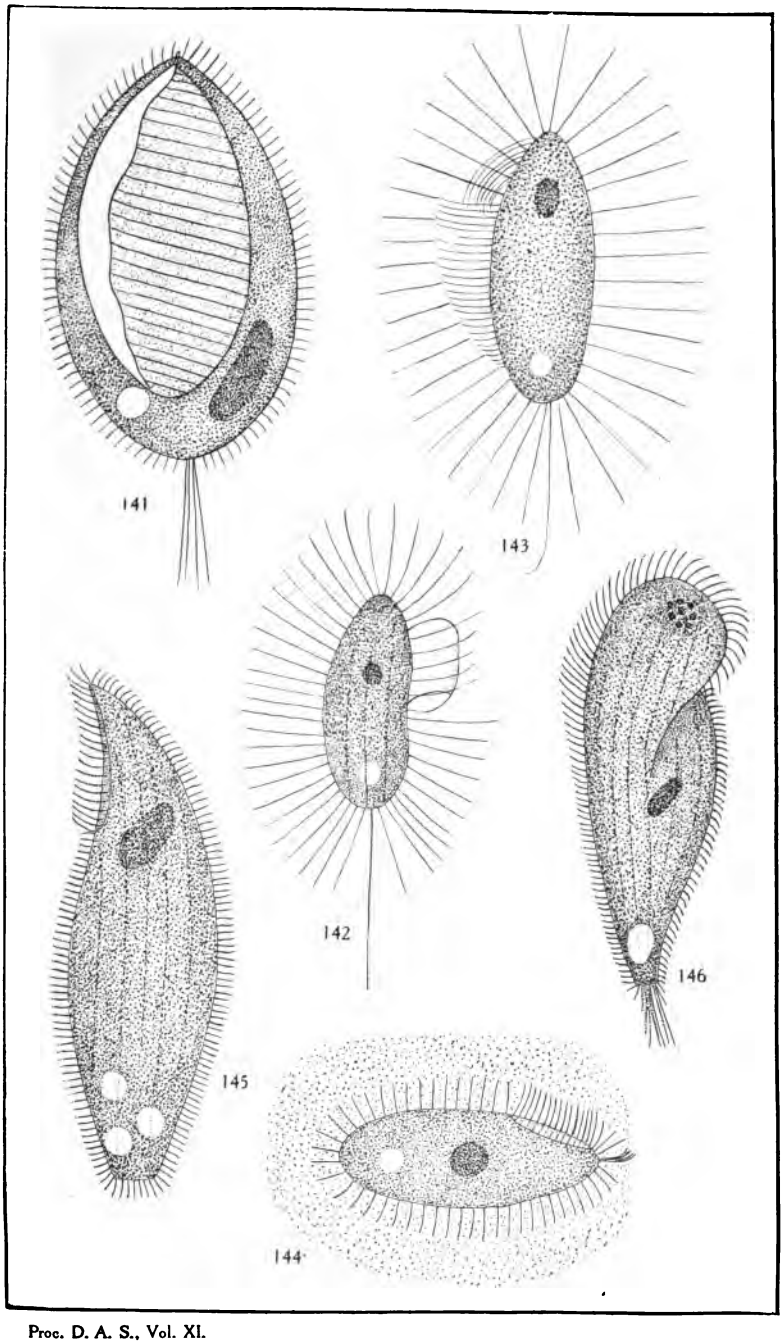

PLATE XX.

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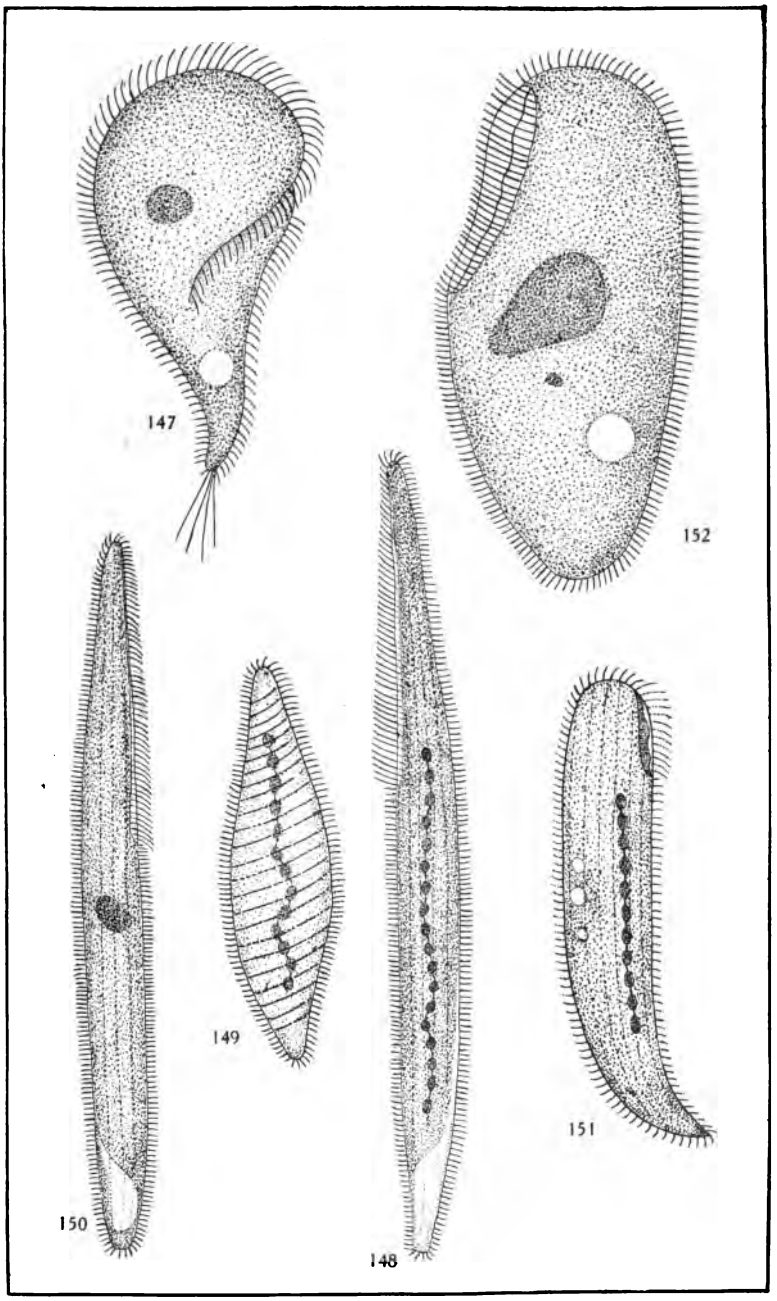

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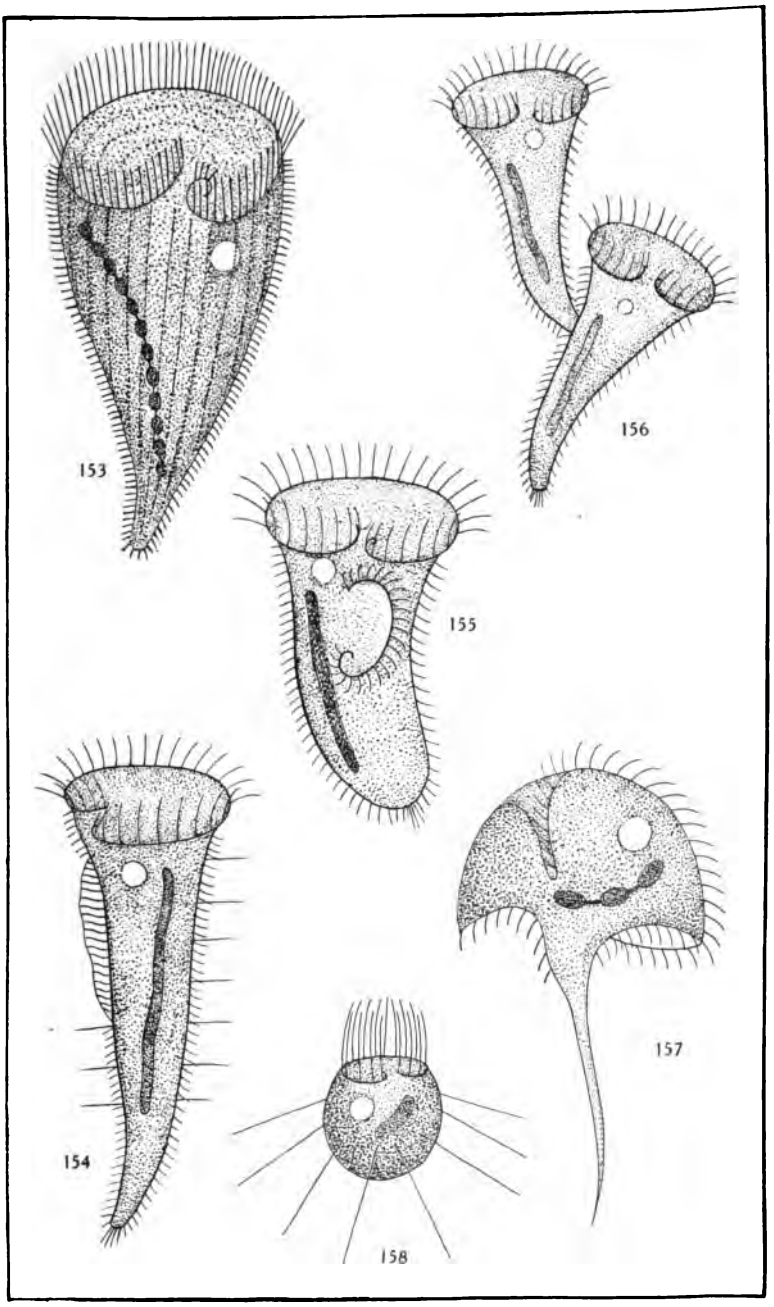
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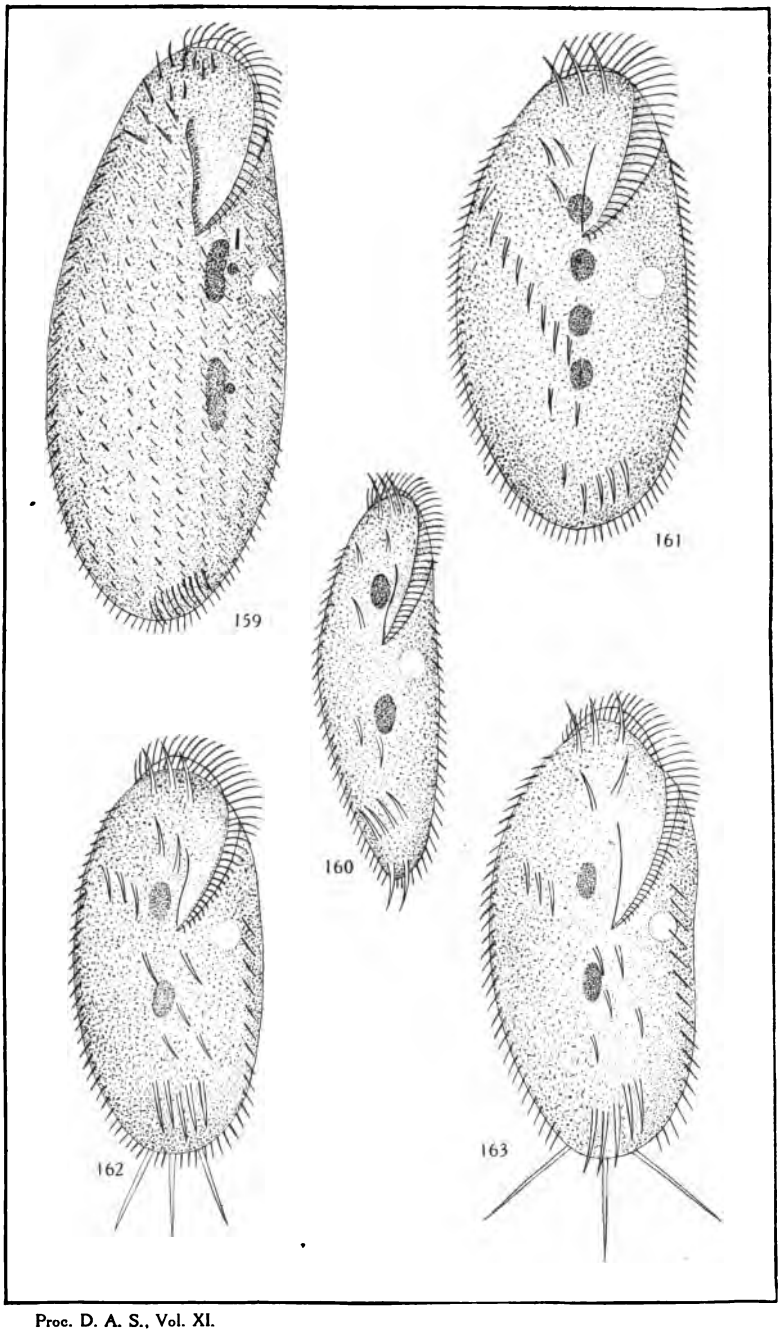
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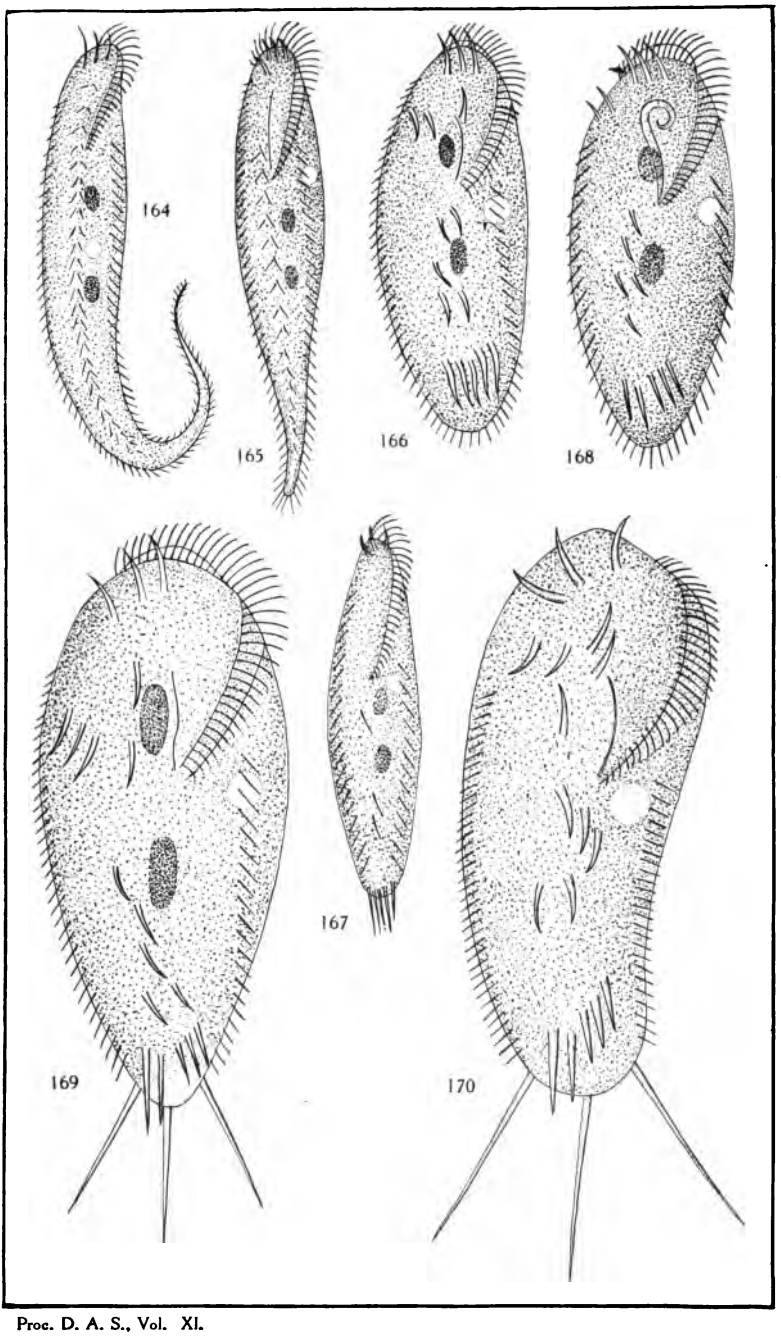
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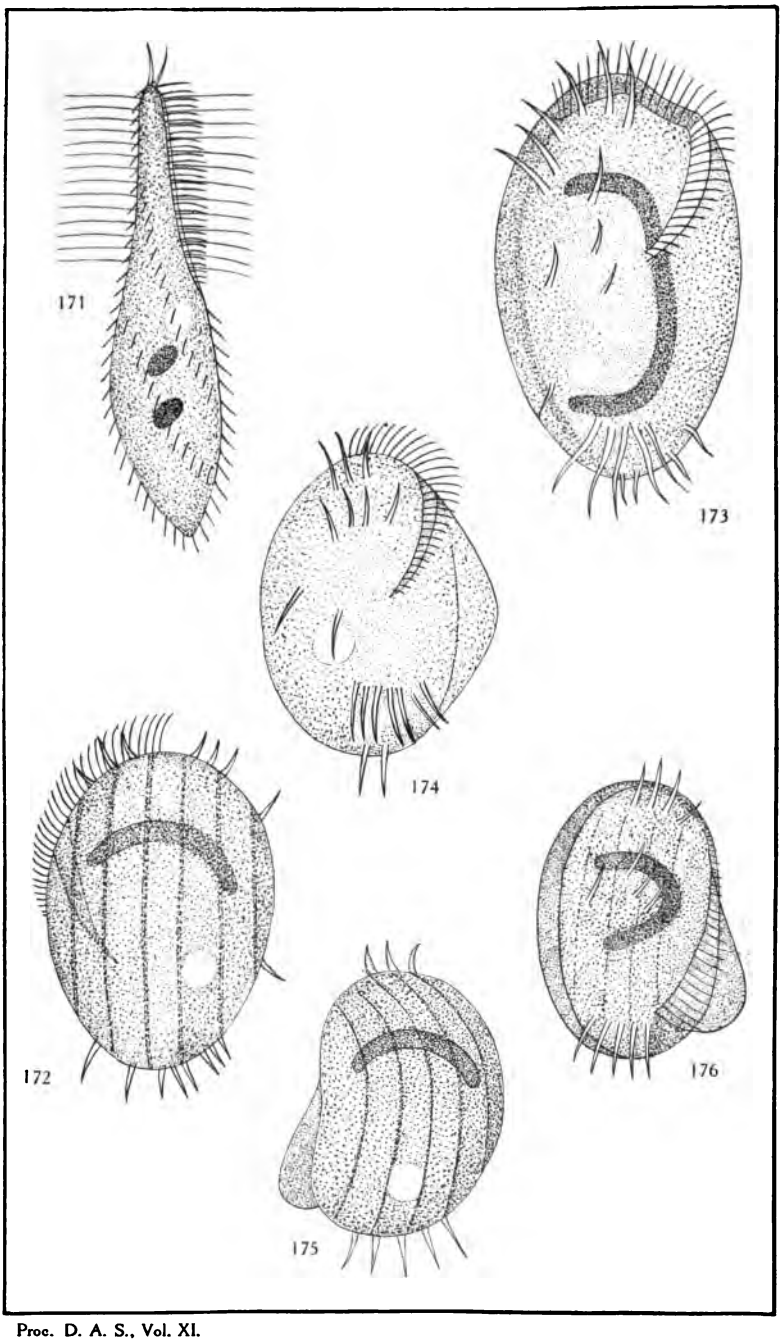
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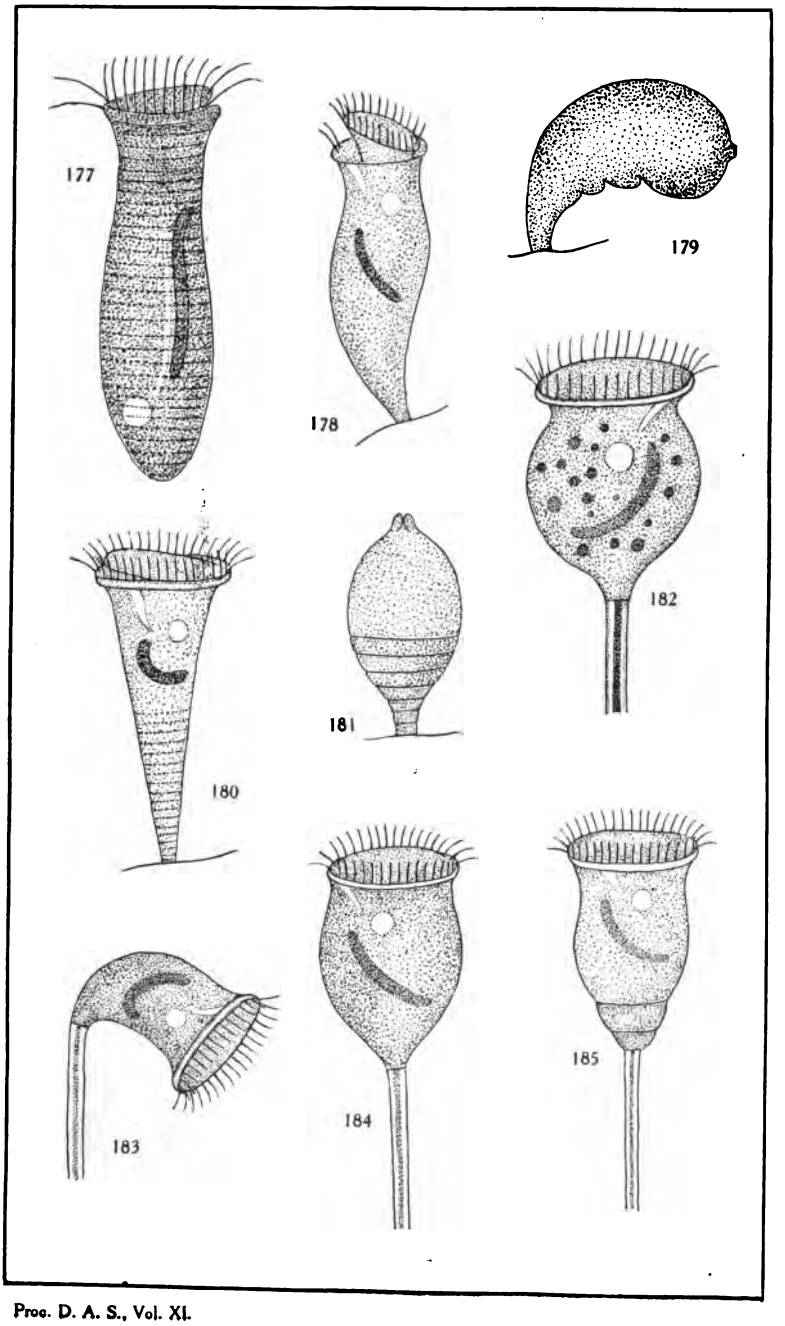
PLATE XXV.

PLATE XXV.



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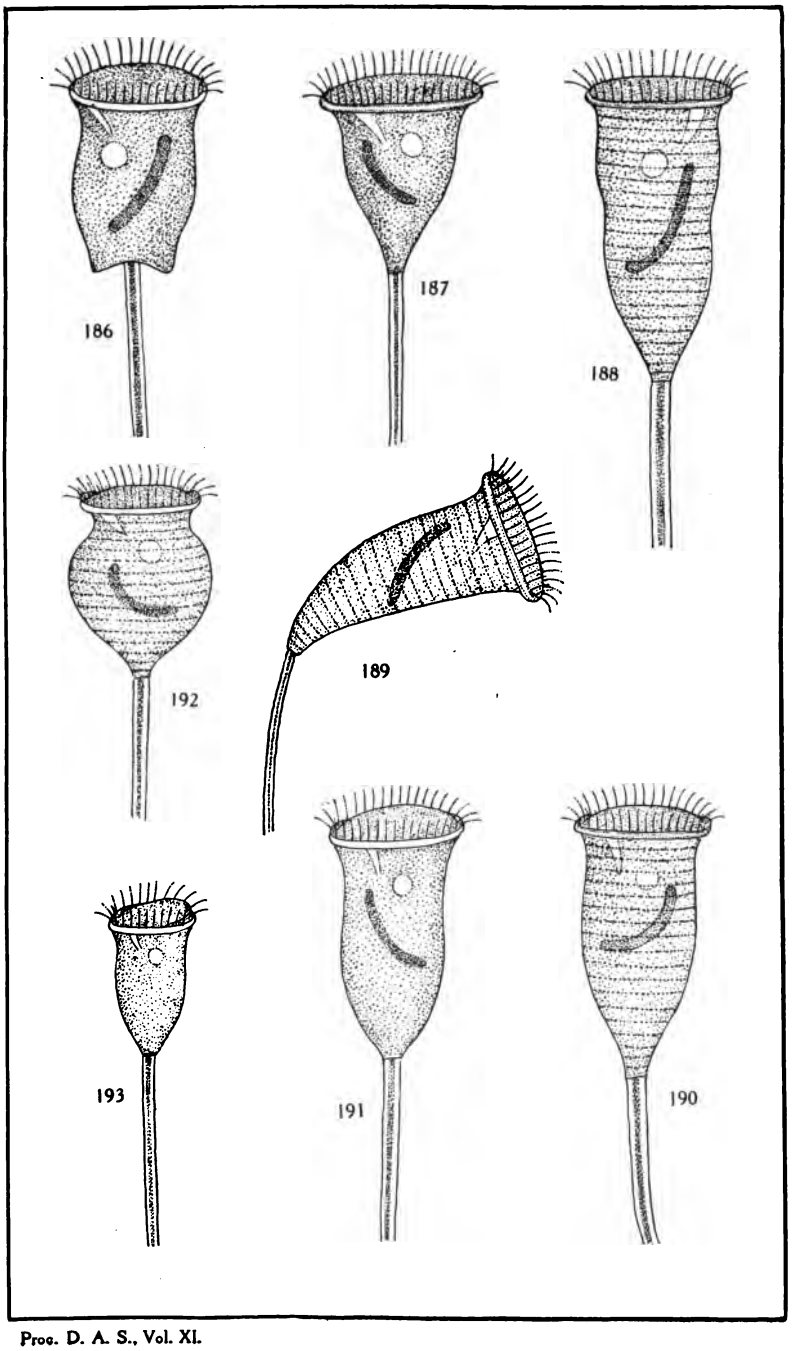
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PLATE XXVII.

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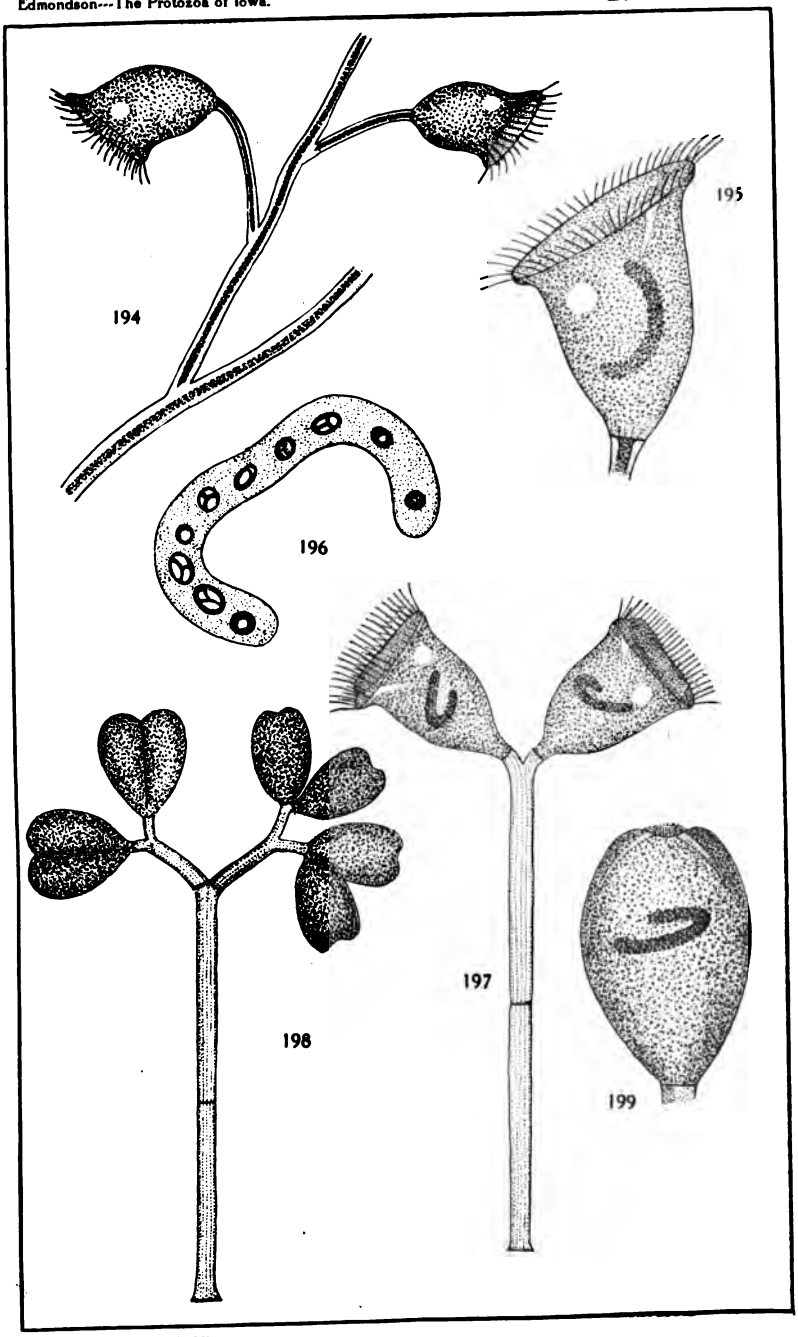

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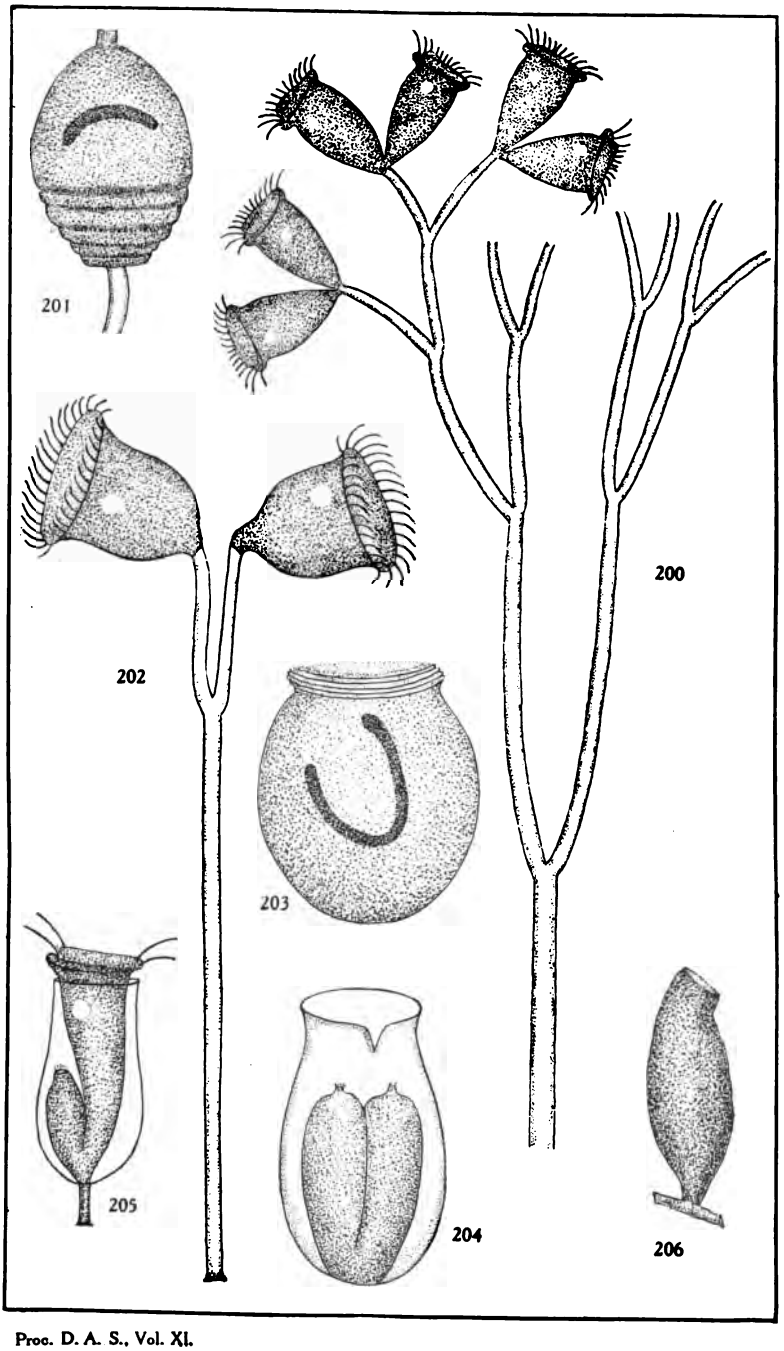
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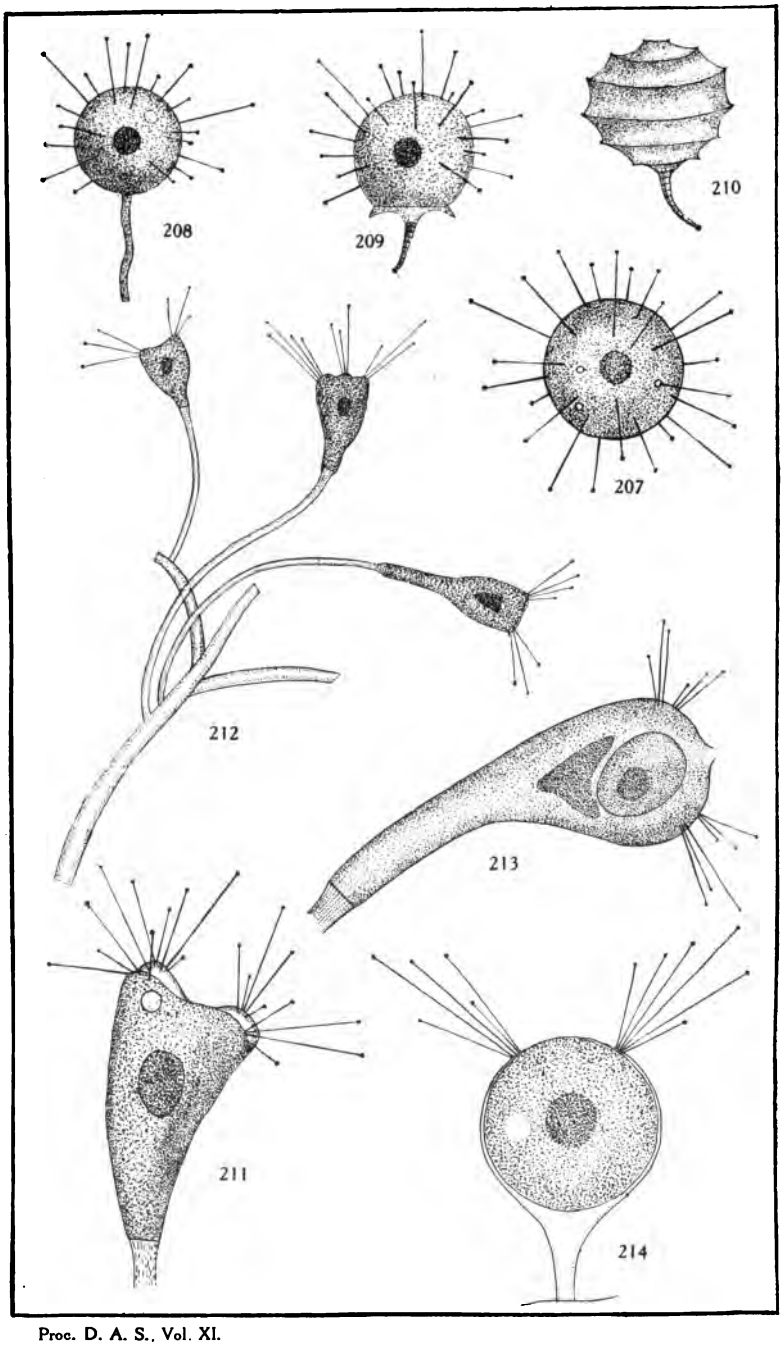
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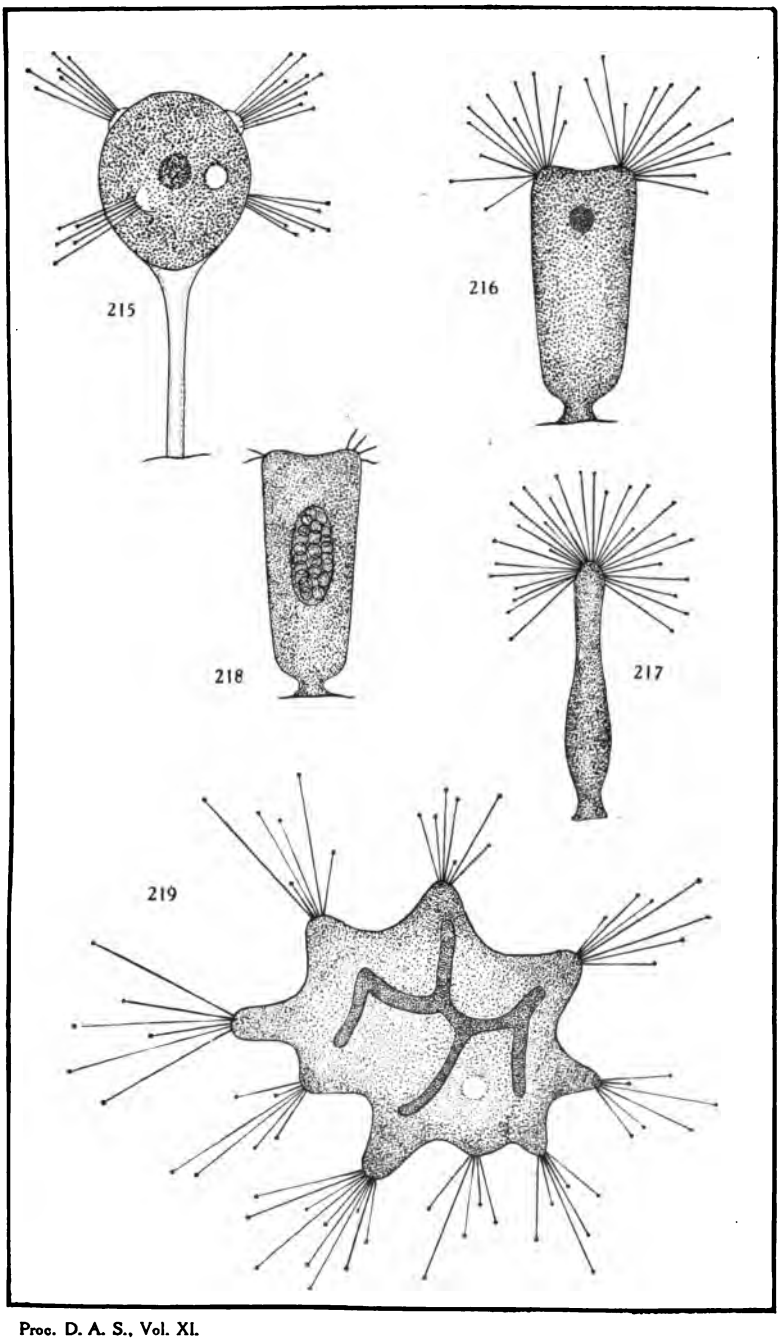
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